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W 72-10313

PB 210 410

The River Basin Model:

UTILITY DEPARTMENT

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The RIVER BASIN MODEL replicates interactions taking place between the local water system and the full range of regional activities within a real or hypothetical area. It is a man-machine simulation model using a gaming format; it is a model of an entire regional system with water a subsystem realistically interacting with the other major subsystems. The model is a computer assisted decision-making tool providing programs to which its users present inputs on behalf of business activities in the Economic Sector, groups of people or population units in the Social Sector, and government departments in the Governmental Sector. The Governmental Sector and the model required by its Utility Department are described. A principal function of the Governmental Sector is to provide public services, and its participants are elected and appointed public officials. The Utility Department is responsible for providing the utility and water and sewer services which economic activities require in order to operate. The Department's utility operations are separate from its water and sewer operations but both are funded from the Department's general budget. (Bell-Cornell)

(See also W72-10307)

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The RIVER BASIN MODEL:

Utility Department

by

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for the
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I. INTRODUCTION TO THE MODEL

A. Brief Description of the Model

In a sense, the RIVER BASIN MODEL is a misnomer because if one places an emphasis on "River" it leads one to believe that the model is primarily concerned with water management. The emphasis should be placed on "River Basin", and that term should be interpreted in its broadest context as meaning a geographical area of land. Through its two major components -- human interaction and computer simulation -- the model represents the economic, social and governmental activity that takes place within the geographical boundaries defined by the river basin or more simply by a group of continguous counties.

The model is unlike most other simulation or human interaction models. It was not designed to accomplish any one specific purpose. Rather it was designed to let its users represent the major economic, social, and governmental decision-makers who cause a regional system to function and change on a year-to-year basis. As part of the functioning of this regional system, water is demanded by industries and municipal water suppliers and pollution is generated by manufacturing and commercial activities, by people, and by farm activities.

The model is a computer-assisted decision-making tool, in which a number of computer programs simulate major processes that take place in the local system such as migration, housing selection, employment, transportation, shopping patterns, the allocation of leisure time, and water quality determination. Users of the model provide inputs to these programs on behalf of business activities in the economic sector, groups of people or population units in the social sector, and government departments in the government sector.

Normally, the users of the model are assigned decision-making responsibility for businesses, population units, and government departments in a gaming format. This means that users become members of teams that are assigned control of:

1. Economic Assets: cash, land, manufacturing plants, outside investments, commercial activities, and/or residences.
2. Social Assets: population units that are designated as high income, middle income, and/or low income.

3. Government Assets: power of the budget, taxing and assessing authority, service responsibility, and planning and regulatory power.

The computer print-outs for a year provide a detailed description of the regional area represented by the model, and the users of the model evaluate this status as individuals, as team members, and collectively to define problems, establish objectives, develop strategies, implement plans, and react to feedback from the new computer printout for the next year.

The initial starting position shows a particular set of allocations of the locals system's resources and their effects on the status of the local area. The users of the model evaluate their own particular status within the local system as well as the status of the area as a whole. They then interact with one another in a dynamic decision-making environment in which they collectively have control over the local water quality decisions that will be made, implemented, and reacted to. Some of the model players may have apparently only marginal interests in the local water quality issues because they are pre-occupied with running schools, building roads, earning incomes, producing manufactured goods, building housing, and supplying local goods and services. Others will have maybe more interest as they attempt to be elected into public office, run the planning department, collect taxes, recreate, and develop a generally pleasant environment for their new residential subdivisions. Still others might have a direct and pressing interest in the local water quantity and quality as they attempt to set and enforce water quality standards, supply municipal water, use surface water in their production process, and benefit from major water-based recreation areas.

In short, the entire local system is represented by the model and its users, and water decisions are placed within their realistic context of having different importance to different individuals as a function of their occupation, location, resources, and personal inclinations.

B. The Three Sectors

The model contains three basic decision-making sectors: economic, social and public. (Figure 1) Every city or region contains these three vital sectors whose interactions cause the area to function and to either grow and prosper or stagnate and decay. Decisions made by one group ultimately affect others

Figure 1

THREE DECISION-MAKING SECTORS AND CONSTITUENT TEAMS

ECONOMIC TEAMS
(Identified by single letter
codes: A, B, C, etc.)

INDUSTRIAL DECISION-MAKER

- HI-Heavy Industry
  - FL-Furniture and Lumber
  - SG-Stone Clay and Glass
  - MP-Primary Metals
  - MF-Fabricated Metals
  - NL-Nonelectric Machinery
  - EL-Electric Machinery
  - TE-Transportation Equipment

- LI-Light Industry
  - FO-Food
  - TA-Textiles and Apparel
  - PA-Paper
  - CR-Chemicals, Plastics and Rubber

- NS-National Service

COMMERCIAL DECISION-MAKER

- BG-Business Goods
- BS-Business Services
- PG-Personal Goods
- PS-Personal Services

RESIDENTIAL DECISION-MAKER

- RA-Single Family
- RB-Garden Apts. and Duplex
- RC-Multiple Unit and High Rise

GOVERNMENT TEAMS
(Identified by the specific
code preceding the department name)

- CH-Chairman of Jurisdiction
- CO-Councilman
- AS-Assessment and Finance
- SC-School
- MS-Municipal Services
- UT-Gas, Electric, Water and Sewer
- HY-Highways
- BUS-Bus Company
- RAIL-Mass Transit Agency
- PZ-Planning and Zoning

SOCIAL TEAMS
(Identified by double letter
codes: AA, BB, CC, etc.)

- PH-High Income
- PM-Middle Income
- PL-Low Income

and one group often works against another group to achieve its goals. For example, proposed commercial developments by an economic group in a predominantly residential area can be blocked by residents of that area just as proposed changes by the government departments can be opposed by those participants in the economic or social sector.

1. The Economic Sector

Economic decision-makers are those businessmen who operate industrial, commercial, residential and farm establishments. Upon receiving output at the beginning of the round economic decision-makers review their economic status and make decisions for the present round. The various economic activities in the model have the following characteristics:

Basic Industry

Heavy Industry, Light Industry and National Services spend money for business goods and business services, utilities, a labor force, transportation, and taxes. In order to produce basic industry output which is then sold to the national markets at prices determined by national business conditions (the computer), owners of basic industries can make a wide variety of decisions. These decisions include purchasing land, changing salaries or maintenance levels, boycotting business goods and business services establishments, acquiring laons, building new businesses, upgrading existing businesses, demolishing old ones, and treating effluents that are dumped into the local water system.

The basic industry of the economy can be further subdivided into the following categories:

HI - Heavy Industry

- FL - Furniture and lumber
- SG - Stone, clay and glass
- MP - Primary metals
- MF - Fabricated metals
- NL - Non-electrical machinery
- EL - Electrical machinery
- TE - Transportation equipment

LI - Light Industry

- FO - Food
- TL - Textile, apparel and leather
- PA - Paper
- CR - Chemicals, plastics, and rubber

NS - National Services

Commercial Establishments

Business goods (BG) and business services (BS), personal goods (PG) and personal services (PS) spend money on many of the same items as basic industry in order to maintain a level of service capacity. This service capacity is consumed or partially consumed by local customers which include: the industrial sector, other commercial establishments and the population units (Pl's) who live in the city. Owners of the commercial establishments may make most of the decisions that owners of basic industries make in addition to setting prices for their products.

Residences

Single-family (RA), townhouse (RB), and high-rise (RC) residence units spend money on personal goods and personal services, utilities, and taxes, and earn income based on rent charged and the number and type of occupants residing in their housing units. Owners of residences may make the same types of decisions made by owners of basic industry in addition to setting the rent paid by their tenants.

Farms

Farm owners make very few decisions aside from how their land will be utilized and what level of fertilizer use they will employ.

2. The Social Sector

Decision-makers in the social sector represent the citizens who live and work in the simulated area. People are represented in terms of population units (Pl's). Each population unit represents fixed numbers of people (500). Population units are divided into three socio-economic groups: high income (PH), middle-income (PM) and low-income (PL). Because each class possesses its own expectations and behavioral patterns, each will have different preferences for residence, job, and schooling, etc. Social decision-makers can vote on behalf of the Pl's which they represent. Voting power is dependent upon the number of population units controlled, the number of registered voters in each, and their socio-economic class. Social decision-makers can also direct the population units under their control to boycott places of employment or shop locations. Social decision-makers can also allocate leisure time of their population units to be spent in any of four basic activities: extra work, adult education (public or private), politics, and recreation. The amount of time spent on each of these activities has an effect on the socio-economic status and/or the dissatisfaction index of people living within the city.

A significant part of the model centers around how Pl's function within the local system during the course of each round of play which represents one year of time in the local area. Figure 2 shows the actions of Pl's as they are affected by the major operating programs.

3. The Public Sector

In the model, the government sector deals with the problems of education, highways, municipal services, planning, zoning, utilities, water supply and quality and bus and rail transportation. The public sector is divided into two basic components. The first component includes elected officials: the Chairman and the Council. These officials are elected by the social decision-makers representing the people who live in each jurisdiction. The Chairman and Council set tax rates, approve budgets, grant subsidies and appropriations, and make appointments. Appointed officials named by the Chairman are heads of these six governmental departments: Assessment (AS), Schools (SC), Municipal Services (MS), Highway (HY), Planning and Zoning (PZ), and Utilities (UT). The Bus and Rapid Rail Companies are semi-private organizations which also may be appointed by the Chairman. Players representing these departments make decisions which include allocating capital and current funds, changing salaries and maintenance levels, requesting federal-state aid, changing district boundaries, constructing or demolishing public buildings, upgrading public buildings, changing levels of service, and transferring cash between accounts.

Figure 2

Example of How Population Units Are Affected by the Major Operating Programs of the Model

Major Operating Programs	Effect on Population Unit
Migration	Pl's move to the local system, find and change housing within the local system, leave the local system
Water System	Poor water quality incareses dissatisfaction and high coliform count increases health costs and time lost due to illness.
Depreciation	Housing that depreciates becomes less attractive in the migration process.
Employment	Pl's are assigned to full and part time jobs that maximize net income (salary minus transportation costs), employers search for best educated workers.
Transportation	Pl's travel to work by the mode and route that minimizes total costs (dollar plus time), Pl's travel to shopping along the minimum cost routes.
School Allocation	Students of Pl's are assigned to public or private schools based upon the quality of public schools.
Park Allocation	Pl's are assigned to parks within a specified distance of where they live.
Time Allocation	Involuntary expenditures of leisure time are calculated as a function of the success of getting part time jobs, public adult education and the time spent on transportation.
Commercial Allocation	Pl's are assigned to stores at which the total costs are minimized (price plus transportation to the store).

C. The Water Component

The water component is a subsector that, in a sense, cuts across the other three sectors or is a part of each. For example, some of the industrial activities in the economic sector use surface water in their production process and all other economic businesses have some need for municipally supplied water. Population units in the social sector use water as a function of their income class and the type of housing they inhabit. In the government sector, the Utility Department is responsible for supplying the municipal water needs of the residents of its jurisdiction.

Each of the surface water users requires a specified quality of water and must either treat the water they intake or purchase water from a source outside of the local system. Every water user adds some pollutants to the water it returns to the water system. If left untreated, these water discharges may lower the quality of water of the body of water into which they are dumped. Since water users and polluters are located in a geographical space, acitivities upstream and downstream are affected differently by the dynamically created water quality conditions.

D. The Local System

The particular regional configuration being used is represented on a grid map consisting of 625 squares. Each square is of equal size and represents 6.25 square miles, 2.5 miles on a side. The grid and all of the computer maps are keyed to a coordinate system. Each parcel can be identified by its coordinates. Horizontal coordinates range from 70 to 118 and vertical coordinates from 12 to 60. Intersections are identified by the odd-numbered coordinates and highways are identified by even-odd (east-west) or odd-even (north-south) coordinates. In all cases, the horizontal coordinate (i.e., the larger number) is identified first.

For example, on the map in Figure 3 the shaded parcel is identified as 7014. Further, the four mile highway indicated by ZZZ is identified as 7217, 7417, 7617, 7817, while the two mile highway indicated by XXX is identified as 7318, 7320. The intersection marked by 0 is located at 7317.

Figure 3

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E. The Unit of Time -- A Round

In the model, a round represents a year of change in the life of the simulated area. From the standpoint of the participants, however, a round may be thought of as a decision-making cycle which starts when they receive their computer output and ends when they hand in their decision input forms for processing by the computer.

During the early part of the typical round, decision-makers will be simultaneously reviewing their computer output and attempting to organize their possible actions. Economic decision-makers, for example, will probably attempt to acquire parcels of land that look good for future development purposes. They may attempt to secure loans from local or outside sources, apply for zoning changes, request utility expansions, and lobby for increased highway access. At the same time, social decision-makers might be bargaining for higher wages, requesting improvements in local schools and municipal services, lobby for higher water quality in the local river, and trying to promote those politicians who see things their way.

Meanwhile, the governmental decision-makers may be receiving requests from the economic and social decision-makers to lower taxes, improve schools, provide better municipal services, expand highways, build additional utilities, enlarge the park system, and improve other services. Budget officials are faced with the task of finding additional revenue to meet expanding public needs and dividing appropriations among the many local departments, all of which have attempted to justify their expanding budgets. Also the government office concerned with water quality might be pressuring the polluting industries to treat their wastes or face regulatory action. All water users might be concerned with water quality and quantity in so far as it affects their cost of using water and doing business.

Toward the middle of the round, it becomes clear to many decision-makers that all of their requests will not be granted. Thus, trade-offs and bargains must be made. Elected officials will begin to worry about staying in office. Departments must often plan to operate with less funds than they had requested. Low income representatives attempt to make their political power felt. High-income representatives attempt to maintain their status. Businessmen begin to look for short-cuts to reduce their losses and increase their activity and profit-making ventures. The water quality office begins to act upon its earlier threat.

As the round approaches a conclusion, the participants formalize the bargains they have made, continue to fill out their decision forms, terminate the negotiations on new wage levels, new prices and new rents, carry on their boycotts and complete any other possible actions. All water related decisions by the private and public decision-makers are completed. Treatment plants are built, industries shut down, fine levied, sampling stations constructed, etc.

When the round ends, participants campaign and carry out new elections, hold town meetings, debrief their actions, and develop new strategies while the computer performs its functions and prepares new output on the status of the simulated city.

F. The Function of the Computer

In the model, players are able to exercise a number of decision alternatives. Only some of these will be communicated to the computer, the rest will be part of the constant communication, bargaining and negotiating carried out in the game-room itself.

The computer performs several major functions in the model.

First, it stores all the relevant economic, social and governmental statistics for the area; updates data when changes are made; and prints out yearly reports on the status of the local system and reports for the economic, social, and government decision-makers.

Second, the computer simulates the actions of the outside system. For example, the computer simulates both a national business cycle, the probabilities of federal-state aid and interest rates on most loans.

Third, the computer performs certain routine functions or processes that would be time-consuming if the players themselves were to perform them. For example, the computer assigns workers from population units to jobs under the assumption that workers will attempt to earn as much money as possible. Other processes include assessing all property, assigning buyers of goods and services to shop at particular commercial establishments, assigning children to public or private schools based upon the capacity and quality of the public schools, and assigning population units to residences based on their desirability. The computer also simulates the migration process which moves population units into, out of, and within the local system. It also measures all of the types of pollution at all points along the river system and calculates a comprehensive water quality index.

II. THE GOVERNMENT SECTOR

A. Introduction to the Sector

The GOVERNMENT SECTOR represents the management apparatus for the public sector of the area represented by the model. Participants in this Sector are the elected and appointed public officials. The Government Sector can make public policy, implement plans and programs, provide public services and raise and disperse funds. The model is sufficiently flexible that the Government Sector can be operated using strong central control or somewhat autonomous departments as determined by the participants. There is a separate government apparatus for each of the political jurisdictions represented by the model. Thus, intergovernmental cooperation and competition may evolve during the play.

B. Sector Functions

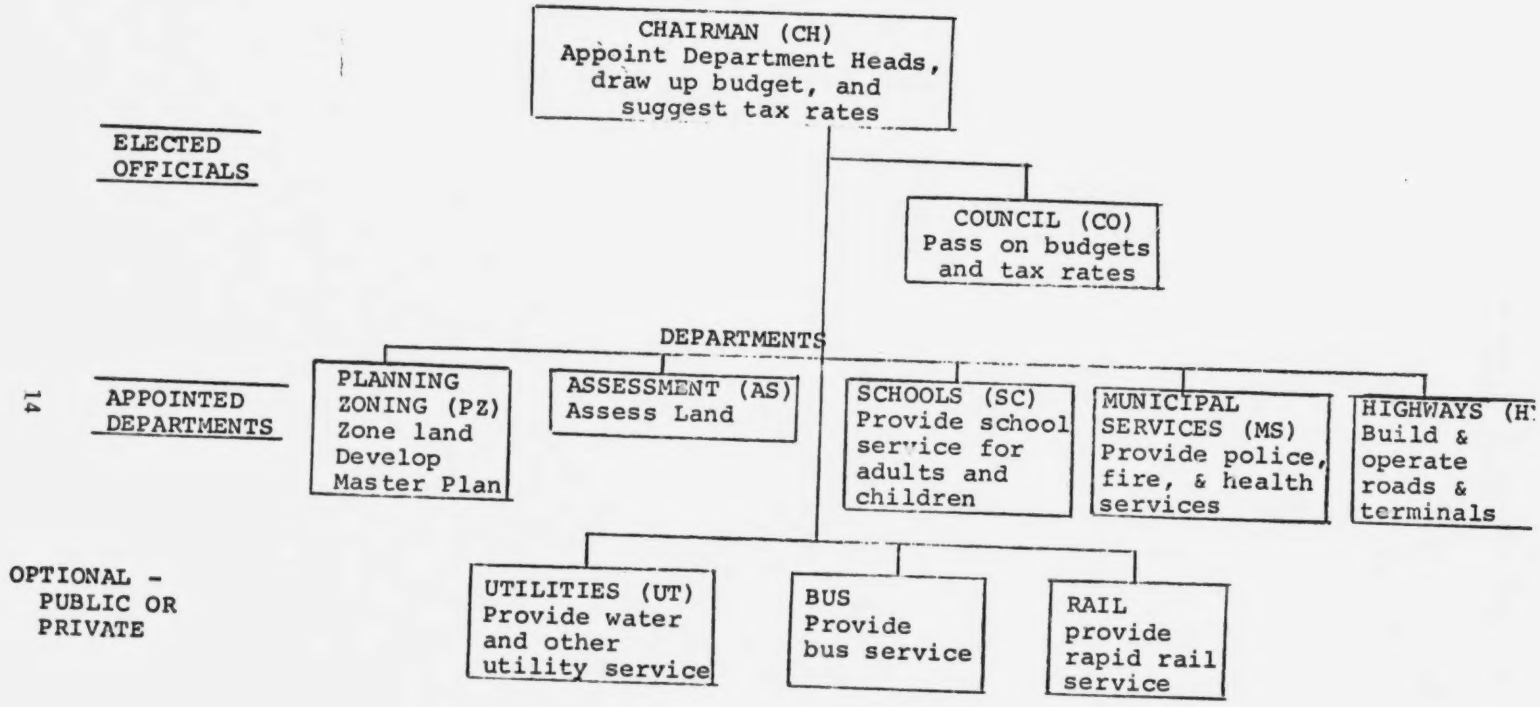
Figure GV1 shows the government structure that may exist in each of the local systems. The Bus and Rail Departments are systemwide functions, whereas the other departments operate on a jurisdiction basis. As noted, the Chairman (or Mayor) and Council are elected in each of the jurisdictions, and the department (staff) decision-makers are appointed by the chairman. The optional public departments, Utilities, Bus and Rail are usually part of the Government Sector, as quasi public functions, but they can also be operated as private (economic) sector activities either initially or as a result of participant action (public sale). The codes used to identify the government functions are shown in parentheses after the function name in Figure GV-1.

Elected officials are accountable to the electorate (the social sector). They are required to respond to public hearings, propose and defend referenda on certain issues, and stand for election. The manner in which elected officials exercise power and conduct their administration and public affairs, however, is at their discretion.

Appointed Department representatives are responsible to the Chairman and Council. However, the presence or absence of effective leadership and communication may influence this relationship and staff decisions. The Government Sector decision-makers depend for their political life on the votes of the social sector. Their relationship with the business community is determined by their own view of public office and public service.

GV-1

GOVERNMENT STRUCTURE


CHAIRMAN (CH)
Appoint Department Heads, draw up budget, and suggest tax rates
ELECTED OFFICIALS
COUNCIL (CO)
Pass on budgets and tax rates
DEPARTMENTS
APPOINTED DEPARTMENTS
PLANNING ZONING (PZ)
Zone land
Develop Master Plan
ASSESSMENT (AS)
Assess Land
SCHOOLS (SC)
Provide school service for adults and children
MUNICIPAL SERVICES (MS)
Provide police, fire, & health services
HIGHWAYS (H
Build & operate roads & terminals
OPTIONAL - PUBLIC OR PRIVATE
UTILITIES (UT)
Provide water and other utility service
BUS
Provide bus service
RAIL
provide rapid rail service

C. Administrative (Non-Decision) Functions

Any number of additional administrative functions can be created to approximate local structures or to examine a variety of administrative mechanisms. While these optional functions do not make direct input decisions to the computer, they may be created to have as much advisory, regulatory or "legal" influence as the participants (or Director) determine. An ENVIRONMENTAL QUALITY CONTROL Commission, for instance, could be established to act as a regulatory agency in the area of water quality and as such could influence current economic activities and future development.

D. Government Decisions

The Government Sector decisions cover a wide spectrum of municipal and public service activities. The types of possible decisions are listed in Figure GV-2, with an indication of the individual decision-makers with primary interest or responsibility. Complete descriptions are in each decision-maker's manual.

In the model, as in the real world, the government can anticipate the emergence of pressing issues related to jobs, housing, economic development, education, public transit, and the environmental quality of their region.

This issue may, for example, occur in the form of special zoning requests, substantial school budgets for adult education, or adamant citizen demands for clean water, increased recreation facilities or lower utility rates.

E. Government Output

It rarely happens that the government has all the information it wants, or needs, to make perfect decisions. Many decisions, under pressures of time, will be typical "guesstimates" - intuitive actions. It is possible, however, for each activity to develop an effective information system using the available resources in the model.

For the local system, the general output is usually posted each round and is available to all decision-makers for general information and analysis. The general output makes available to each participant, in maps, detail and summary form, extensive current and comparative information about conditions, trends and characteristics of the region. The range of information in the maps and the items of General Output cannot be overemphasized. Experience

GV-2

GOVERNMENT SECTOR DECISIONS

TYPE OF DECISION	PRIMARY INTEREST CH CO	AS	SC	MS	HY	PZ	UT	BU	RA
Grant Appropriations	x								
Grant Subsidies	x								
Transfer Cash	x		x	x	x	x	x	x	x
Set Welfare Payments	x								
Set Tax Rates	x								
Float Bonds	x								
Assess Land, Buildings		x							
Buy and Sell Land			x	x	x	x	x		x
Establish Government Jobs			x	x				x	x
Establish Maintenance Levels of Government Facilities			x	x	x			x	x
Establish Service Districts			x	x			x		
Request Federal State Aid	x		x		x				
Establish Employee Salaries			x	x				x	x
Build and Demolish Schools			x						
Establish Adult Education Programs			x						
Build and Demolish Municipal Service Plants				x					
Contract to Purchase Goods and Services			x	x					
Construct and Demolish Roads					x				
Construct and Demolish Terminals					x				
Zone Land						x			
Create and Demolish Public Institutional Land Uses						x			

GV-2 (Cont.)

GOVERNMENT SECTOR DECISIONS

TYPE OF DECISION	PRIMARY INTEREST CH CO	AS	SC	MS	HY	PZ	UT	BU	RA
Provide Parkland						x			
Install Utility Services							x		
Set Utility Service Prices							x		
Construct and Demolish Utility Plants							x		
Locate Public Transit Routes								x	x
Buy and Sell Rolling Stock								x	x
Set Fares								x	x
Establish Amount of Transit Service								x	x
Construct Rail Lines and Stations									x
Set Water Prices							x		
Construct Treatment Plants (intake and outflow)							x		
Specify Intake and Outflow Points							x		
Establish Water Sampling Stations									
Set Dam Priorities	x						x		

with the model has indicated that decisions are facilitated if the participants use the General Output information as part of their decision process.

The complete government sector output consists of the information, maps and detail made available to each government decision-making function of the government. Each government function has available to it a comprehensive portrayal of its status and the conditions which pertain to its activities.

F. Government Budgetary Procedures

The same general financial accounting procedure is used for all government departments, including Utilities, Bus and Rail. Department budgets are divided into Capital and Current accounts. Departments may transfer funds from one account to another, but no automatic transfers will take place. Appropriations, subsidies, and cash transfers to departments must be directed to either the capital or current account.

The Chairman's account has only a current account, the Planning and Zoning Department has only a capital account, and the Assessment Department has no financial accounts. All other departments have both accounts.

The Chairman makes appropriations, and subsidies from his current account before he actually receives income to his account. His is the only department which makes expenditures before income is calculated. Once a department has received an appropriation, the money is never automatically transferred back to the Chairman's account. If the Chairman spends more than he later receives in revenue, a current bond is automatically floated in the Chairman's name and is paid off from the Chairman's account. If a department spends more than its revenues (this can only happen in a department's current account), a current bond is floated in the department's name and is paid off from the department's account.

The following format is contained within each account:

Previous Cash Balance
Revenues
Expenditures
New Cash Balance.

If the output is for round T, then Previous Cash Balance would be equal to the New Cash Balance for round T-1.

Expenditures may not be made from capital accounts unless there is sufficient cash to cover the expenditure. Therefore, the cash balance in a capital account is always greater than or equal to zero; the cash balance in the capital account may not be negative.

If expenditures from the current account are greater than previous balance plus revenues, then a short term bond (current or two-year) is automatically floated to cover the deficit. Therefore, the New Cash Balance may never be negative in the current account. Because of rounding, the New Cash Balance will normally be slightly positive (rather than zero) even in the case where a short-term bond had to be floated.

All capital expenditures are player or director decisions which have been submitted during the previous EDIT. Current expenditures are made according to government policies which may have been established in any previous EDIT. Current expenditures (except miscellaneous expenditures) do not directly reflect player decisions; they are functions of policies. For example, a player sets the salaries and number of job openings which the School Department offers, but other local conditions influence how many employees the department actually hires and thus influence the amount which the department pays in salaries.

The most common capital revenue sources for departments are appropriations (for MS, SC, HY, and PZ), capital bonding for 25 years (all departments), Federal-State Aid (SC, HY) and miscellaneous sources (sale of land, and incoming cash transfers). Special capital revenue sources are subsidies to the Utility Department.

The most common capital expenditures are for construction, land purchase, and miscellaneous (outgoing cash transfers).

The most common current revenue sources are appropriations (all but UT and CH), short term bonding, Federal-State Aid (MS and SC), and miscellaneous income (incoming cash transfers).

Special current revenue sources exist for the Utility Department (income from user charges on utility and water service and subsidies) and the Chairman (taxes).

The most common current expenditures are for bond payments (capital bonds and current bonds together), goods and services (MS, SC, maintenance for HY, and utility operating costs for UT), salaries (MS and SC), and miscellaneous (outgoing cash transfers).

Special current expenditures are for welfare payments (MS), adult education (SC), treatment operating costs and sampling station operating costs (UT), and subsidies (CH).

G. GOVERNMENT MASTER TABLE

(Characteristics are for Level One Development)

	SC	MS	UT	HY	TM	RAIL STATION	RAIL TRACKS (Per Mi)		VEHICLES	
							SURFACE	UNDER-GROUND	RAIL	BUS
CONSTRUCTION COST (Millions of Dollars)	27	30	30	.8M	14	1	4	NA	.8/mi	.4/mi
DEMOLITION COST (Millions of Dollars)	5.4	6	6	.16M	2.8M	NA	NA	NA		
CHARACTERISTICS OF FACILITIES										
Possible Levels of Development	3	3	3	3	3	1	1	1		
Land Requirement (% of a parcel)	16	12	20	8	12	NONE	4	NONE		
Rate of Annual Depreciation (%)	2.0	3.3	NA	5.0	NA	NA	NA	NA	3.5	3.5

	SC	MS	UT	HY	RAIL	BUS	PZ
POSSIBLE SOURCES OF REVENUE TO DEPARTMENTS							
Current Funds							
Appropriations	x	x		x			
Subsidy			x		x	x	
Cash Transfer	x	x	x	x	x	x	
Automatic Bonding	x	x	x	x	x	x	
Automatic Federal State Aid	x	x					
Capital Funds							
Appropriations	x	x		x			x
Subsidy			x		x	x	
Cash Transfer	x	x	x	x	x	x	x
Bonding	x	x	x	x	x	x	x
Federal-State Aid	x			x			
Charges to Users			x		x	x	
Labor Hired	PH PM	PM PL	NA	NA	PM	PM	NA

III. UTILITY DEPARTMENT

A. Introduction

This manual contains the basic information and description of the model required by the Utility Department. It is assumed that the Model Overview, the Scenario, and the Government Sector descriptions have been read prior to the receipt of this manual.

Once the players comprising the Utility Department have become familiar with the model in general, the particular city being represented, and the workings of the local utility system they will be able to bring their own imagination and initiative to bear on the operation of the Utility Department in their specific jurisdiction.

The local Utility Department is given control of a number of resources within the local dynamic system and it will have the opportunity to allocate these resources and change them in such a way as to satisfy self-established goals and/or to respond to pressures brought on it by elected officials and the local citizenry and business community.

B. Utility Department Summary

The Utility Department is responsible for the provision of the utility and water and sewer services which economic activities require in order to operate. The department's utility operations are separate from its water and sewer operations but both are funded from the department's general budget.

Each utility plant has its own district, comprised of full parcels contiguous to the utility plant. A utility district is also a water district, which can contain one water intake treatment plant and one sewage treatment plant. When utility service is installed on a parcel, water and sewer service is also installed.

Utility plants, intake treatment plants, and outflow treatment plants are constructed in levels, each level having a fixed capacity of service. Outflow treatment plants are also constructed as certain types, each type having the ability to remove different amounts of each pollutant type. All of the plants require a fixed amount of land for each constructed level. When a level is demolished, the land becomes available for other Utility Department construction or sale to another owner.

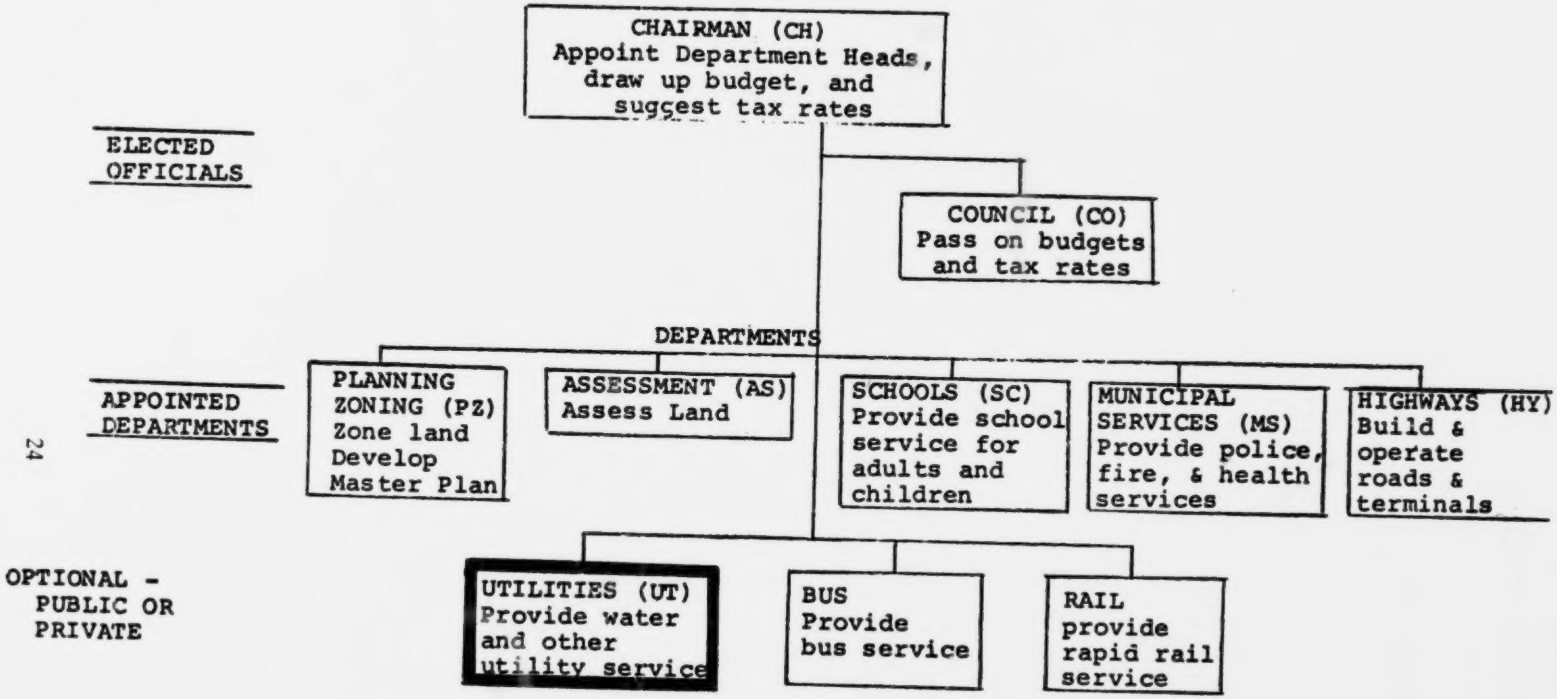
The Department sets the price which any economic activity must pay per utility unit consumer. Each activity does consume a different number of utility units, but the price per unit consumed is the same for every utility user.

The Department also sets the water price per MG consumed, but the price set can vary by the type of economic activity, and, in the case of residences, by class. Utility users always obtain the utility service which they need; the only variable is the price set by the Utility Department. However,the Utility Department might not always be able to provide sufficient water for all of its users' needs. The quantity and quality of water in the local water system affect the costs of providing water service to the local system users.

Figure UT-1 shows how the Utility Department fits into the local government structure. It may be a public or private operation depending upon the wishes of the local system decision-makers in each jurisdiction.

Figure UT-1

THE UTILITIES DEPARTMENT AS IT FITS
WITHIN THE LOCAL GOVERNMENT STRUCTURE



CHAIRMAN (CH)
Appoint Department Heads, draw up budget, and suggest tax rates
ELECTED OFFICIALS
COUNCIL (CO)
Pass on budgets and tax rates
DEPARTMENTS
APPOINTED DEPARTMENTS
PLANNING ZONING (PZ)
Zone land
Develop Master Plan
ASSESSMENT (AS)
Assess Land
SCHOOLS (SC)
Provide school service for adults and children
MUNICIPAL SERVICES (MS)
Provide police, fire, & health services
HIGHWAYS (HY)
Build & operate roads & terminals
OPTIONAL - PUBLIC OR PRIVATE
UTILITIES (UT)
Provide water and other utility service
BUS
Provide bus service
RAIL
provide rapid rail service

IV. COMPUTER PRINTED OUTPUT DESCRIPTION

A. Introduction

The printed computer output provides a yearly report of the status of the simulated region and of interactions within the region during the previous year. There are several types of output: maps showing characteristics of the region which differ geographically; summaries which present information in capsulated form; and detailed information from which the summaries are derived.

The figure on the next page shows the titles of the output sections in the order in which they are printed. That sequence follows neither the logical order of computer program operations nor the usual sequence in which a user examines the output. The code number beside the title of each section of output listed in this figure is the code number used in all examples of output included in this manual. The output is explained in this section in order of most general to most detailed information. Output is explained in the following order:

- maps
- summary information
- general information of relevance to all three sectors
- social sector detail
- economic sector detail
- government sector detail

There are a few standard features of all printed output sections. Each has a title which is a short description of the type of information given by the section of output. Each also contains both the round number and the game heading (the name of the data base being used or some other heading input by the director). Where relevant, a jurisdiction number is also printed.

After a few rounds' experience with the model, a model user usually needs only the printed computer output from a round and the Master Tables and input formats contained in this manual in order to play subsequent rounds.

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RIVER BASIN MODEL OUTPUT

1. Migration
   - 1.1 Environmental Indexes
   - 1.2 Personal Indexes
   - 1.3 Dissatisfaction Cutoffs
   - 1.4 Migration Detail
   - 1.5 Migration Statistics
   - 1.6 Migration Summary
2. Water System
   - 2.1 Water User Effluent Content
   - 2.2 River Quality During Surface Water Process
   - 2.3 Water User Costs and Consumption
   - 2.4 Coliform and Pollution Index Values
3. Employment
   - 3.1 Employment Selection Information for PL Class
   - 3.2 Employment Selection Information for PM Class
   - 3.3 Employment Selection Information for PH Class
   - 3.4 Part-Time Work Allocation for PH Class
   - 3.5 Part-Time Work Allocation for PM Class
   - 3.6 Part-Time Work Allocation for PL Class
   - 3.7 Employment Summary
4. Commercial Allocation
   - 4.1 Personal Goods Allocation Summary
   - 4.2 Personal Services Allocation Summary
   - 4.3 Business Goods Allocation Summary
   - 4.4 Business Services Allocation Summary
   - 4.5 Government Contracts
   - 4.6 Terminal Demand and Supply Table
   - 4.7 Terminal Allocation Map
5. Social Sector
   - 5.1 Dollar Value of Time
   - 5.2 Social Decision-Maker Output
   - 5.3 Social Boycotts
6. Economic Sector
   - 6.1 Farm Output
   - 6.2 Residence Output
   - 6.3 Basic Industry Output
   - 6.4 Commercial Output
   - 6.5 Economic Boycott Status
   - 6.6 New Construction Table
   - 6.7 Land Summary
   - 6.8 Loan Statement
   - 6.9 Financial Summary
7. Social and Economic Summaries
   - 7.1 Number of Levels of Economic Activity Controlled by Teams
   - 7.2 Employment Centers
   - 7.3 Economic Control Summary for Teams
   - 7.4 Social Control Summary for Teams
   - 7.5 Social Control Summary Totals
   - 7.6 Economic Graphs for Teams
   - 7.7 Social Graphs for Teams
8. Government Detail
   - 8.1 Assessment Report
   - 8.2 Water Department Reports
   - 8.3 Sampling Station Report: Point Source Quality
   - 8.4 Sampling Station Report: Ambient Quality
   - 8.5 Utility Department Report
   - 8.6 Utility Department Finances
   - 8.7 Municipal Services Department Report
   - 8.8 Municipal Services Department Finances
   - 8.9 Municipal Services Department Construction Table
   - 8.10 Planning and Zoning Department Report
   - 8.11 School Department Report
   - 8.12 School Department Finances
   - 8.13 School Department Construction Table
   - 8.14 Highway Department Finances
   - 8.15 Highway Department Construction Table
   - 8.16 Rail Company Report
   - 8.17 Bus Company Report
   - 8.18 Chairman Department Finances
   - 8.19 Tax Summary
   - 8.20 Financial Summary
9. Summary Statistics
   - 9.1 Demographic and Economic Statistics
10. Maps
    - 10.1 Personal Goods Allocation Map
    - 10.2 Personal Services Allocation Map
    - 10.3 Business Commercial Allocation Map
    - 10.4 Municipal Service Map
    - 10.5 School Map
    - 10.6 Utility Map
    - 10.7 Water Usage Map
    - 10.8 Water Quality Map
    - 10.9 Municipal Treatment
    - 10.10 Municipal Intake and Outflow Point Map
    - 10.11 Surface Water Map
    - 10.12 Farm Runoff Map
    - 10.13 River Basin Flood Plain Map
    - 10.14 Farm Map
    - 10.15 Farm Assessed and Market Value Map
    - 10.16 Market Value Map
    - 10.17 Assessed Value Map
    - 10.18 Economic Status Map
    - 10.19 Highway Map
    - 10.20 Planning and Zoning Map
    - 10.21 Parkland Usage Map
    - 10.22 Socio-Economic Distribution Map
    - 10.23 Demographic Map
    - 10.24 Social Decision-Maker Map
    - 10.25 Topographical Restriction Map
    - 10.26 Government Status Map

B. Map Output

The model output includes several maps which visually represent characteristics of the simulated region which differ by location. The entire simulated region is represented on a single, two-page computer map. A map key is printed at the bottom of each page. Map symbols appear on a map in the three types of locations which can be specified in the model: parcels (squares), parcel edges (lines separating squares), and intersections of lines (parcel corners). Land uses and other characteristics of parcels are represented within the squares. Divisions between parcels such as roads or jurisdiction boundaries are represented between parcels, and activities such as terminals are represented at parcel corners.

The Map Titles and a brief description of their contents are given below, in the order in which they will be discussed. All information is located spatially.

Economic Status Map: economic owners, economic activities and operating levels, zoning, levels of utilities installed, amounts of undeveloped land, road types, terminal levels, jurisdiction boundaries.

Government Status Map: school levels, parks, municipal service levels, utility plant levels, road types, terminal levels, jurisdiction boundaries.

Socio-Economic Distribution Map: residence types and levels, number of Pl's of each class, road types, terminal levels, jurisdiction boundaries.

Demographic Map: populations, residential quality indexes, business value ratios, percent occupancy, road types, terminal levels, jurisdiction boundaries.

Personal Goods Allocation Map: PG shopping location for each class and residence, PG location.

Personal Services Allocation Map: PS shopping location for each class and residence, PS location.

Business Commercial Map: BG and BS shopping location for each business, BG and BS locations.

Utility Map: utility units served, utility units installed, utility plants, utility district boundaries, jurisdiction boundaries.

Surface Water Map: volumes of surface water, rates of flow, land area in water, directions of surface water flow, lakes.

Municipal Treatment Plant Map: municipal water intake treatment plants and levels, municipal sewage treatment plant types and levels, utility plant locations and code numbers, directions of surface water flow, utility district boundaries, lakes.

Municipal Inflow and Outflow Point Map: Municipal surface water intake points, municipal sewage outflow points, utility districts served by each, surface water qualities, directions of surface water flow, utility district boundaries, lakes.

Water Quality Map: economic activities and operating levels, surface water qualities, directions of surface water flow, lakes.

Economic Sector Water Usage Map: economic activities and operating levels, amounts of recycling, business effluent treatment types and levels, utility district boundaries, jurisdiction boundaries.

Municipal Services Map: economic activities and operating levels, municipal service units required, municipal services and their use indexes, municipal service district boundaries, jurisdiction boundaries.

School Map: numbers of public school students, numbers of private school students, schools and their use indexes, school district boundaries, jurisdiction boundaries.

Highway Map: economic activities and operating levels, road types, terminal levels.

Planning and Zoning Map: zoning, park, public institutional land uses, road types, terminal levels, jurisdiction boundaries.

Parkland Usage Map: parks, populations served by park, park use indexes, road types, terminal levels, jurisdiction boundaries.

Market Value Map: market values of all non-farm land, privately owned buildings, and privately owned land and buildings, road types, terminal levels, jurisdiction boundaries.

Assessed Value Map: assessed values of non-farm privately owned land and buildings, road types, terminal levels, jurisdiction boundaries.

Farm Assessed and Market Value Map: assessed and market values of farms, amount of land in farms, road types, terminal levels, jurisdiction boundaries, lakes.

Farm Map: farm owners, amount of land in farms, farm types, levels of fertilization, road types, terminal levels, jurisdiction boundaries.

Farm Runoff Map: where runoff from farms flows, direction of surface water flow, lakes.

River Basin Flood Plain Map: river basins, dam priorities, flood susceptibility of each parcel, direction of surface water flow, lakes, jurisdiction boundaries.

Topographical Restriction Map: topographically undevelopable land, road types, terminal levels, jurisdiction boundaries.

Social Decision-Maker Map: social decision-maker controlling each class living on each residence parcel, road types, terminal levels, jurisdiction boundaries.

1. Economic Status Map

This map shows the economic sector owners of all privately-owned non-farm parcels and the economic activity, if any, on each parcel. A parcel can have only one economic owner and one economic activity. Owners of farm parcels are shown on the Farm Map. The types of economic activities represented in the model are listed in the Master Tables.

The economic owner of a parcel owns all of the land and developments on the parcel which do not belong to the government or which are not topographically undevelopable. If the economic owner sells land to another economic decision-maker, he must sell all of the privately-owned land and buildings on the parcel to the new owner. An economic decision-maker can sell any portion of undeveloped land on a parcel to a government department.

The Planning and Zoning Department may zone parcels. Zoning is a restriction on economic development. Once a parcel is assigned a particular zoning code, all new economic development on the parcel must conform to the new zoning. If a parcel is unzoned, there is no restriction on what type of activity may be constructed on it. The Economic Status Map key defines what private land uses are allowed under each zoning code.

When a new economic development is constructed on a parcel, it must not only conform to the parcel's zoning; it must have sufficient utility service. Utilities are installed by the Utility Department in "levels" (1 - 9). Each level of economic activity requires a certain number of utility units, and each level of utility service supplies a fixed number of utility units to a parcel.

If an economic decision-maker has insufficient utility service for a proposed development, the Utility Department must install adequate utility service before the new development can be constructed.*

---

*There are two exceptions to the utility restriction on development: 1) RA housing can be built with "private utilities", which do not require utilities supplied by the Utility Department; 2) the director can override the utility restriction on individual developments.

Figure 10.18

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***************************************************************************************************************************
                     TWOCITY
                                                   ECONOMIC STATUS MAP                                              ROUND  2
***************************************************************************************************************************

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38 O    .    .    .    .    .    .    .    .    .  .RA 1ORA 1.RS 3HRA 4.RA 3.    .    .    .    .    .    .    .    .    .    O 38
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.1 98O1 39.1 30H1 40.1 46. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
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40 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 40
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.1 88H1 88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
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42 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 42
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
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44 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 44
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46 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 46
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
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   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
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50 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 50
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
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52 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 52
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
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54 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 54
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
   O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O
56 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 56
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
   O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O
58 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 58
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   O.......................................................O.........H......................................................O
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60 O    .    .    .    .    .    .    .    .    .    .    O    .  H    .    .    .    .    .    .    .    .    .    .    .    O 60
   O 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O 100.  88H  88. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100O
   OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOB

     70   72   74   76   78   80   82   84   86   88   90   92   94   96   98  100  102  104  106  108  110  112  114  116  118

         PARCEL KEY                         PARCEL EDGES               INTERSECTIONS          ZONING  LAND USE    ZONING  USE
TOP LEFT:      OWNER                       .. .. ROADBED            * TYPE 1 TERMINAL         --    ANY USE            33  RS
TOP RIGHT:     ZONING                      -- || TYPE 1 ROAD        X TYPE 2 TERMINAL         10    ANY BUSINESS       34  RC
MIDDLE:        LAND USE AND LEVEL          == HH TYPE 2 ROAD        * TYPE 3 TERMINAL         20    HI,LI,CI           35  PS
BOTTOM LEFT:   UTILITY LEVEL               ZZ WW TYPE 3 ROAD                                  21    HI                 40  RA,RA,RC
BOTTOM RIGHT:  % UNDEVLPD LAND             CO OO JURISDICTION BOUNDARY                        22    LI                 41  RA
                                                                                              23    CI                 42  RB
                                                                                              30    NS,RG,RS,PG,PS     43  RC
                                                                                              31    NS                 50  PARKLAND
                                                                                              32    RG
```

Economic developments also require land. Each activity depending on its type, requires a certain amount of land for each constructed level of development. Regardless of the operating level of an activity, the land consumed is that of the constructed level, which is always greater than or equal to the operating level. The amount of privately-owned land which is not in developments is classified on this map as undeveloped. If a parcel shows no undeveloped land, no further economic development can occur there unless the owner either acquires more land from a government department owning a portion of the parcel or demolishes existing economic developments. An economic decision-maker can acquire land by purchasing a parcel from another economic decision-maker or by bidding on land which is owned by the Outside.

The operating level of an economic activity is shown on the Economic Status Map. For most purposes, a business' operating level is the only level considered by the computer programs. However, a business pays property taxes and maintenance for its constructed level.

2. Government Status Map

Whereas there can be only one economic owner per parcel, any combination of government departments can own developed and undeveloped land on a parcel. The government departments which can own land, and the types of developments each can construct on a parcel are:

Department	Development Type
Utility Department	Utility Plant
	Water Intake Treatment Plant
	Sewage Outflow Treatment Plant:
	Chlorination
	Primary Treatment
	Secondary Treatment
	Tertiary Treatment
School Department	School Unit
Municipal Service Department	Municipal Service Unit
Planning and Zoning Department	Parkland
	Public Institutional Land
Highway Department	Road*
	Terminal*

A government department can sell undeveloped land which it owns to either another government department or to the economic decision-maker owning the privately-owned portion of a parcel.

The government status map shows the locations of some of the types of government activities: schools, parks, utility plants, and municipal service units.

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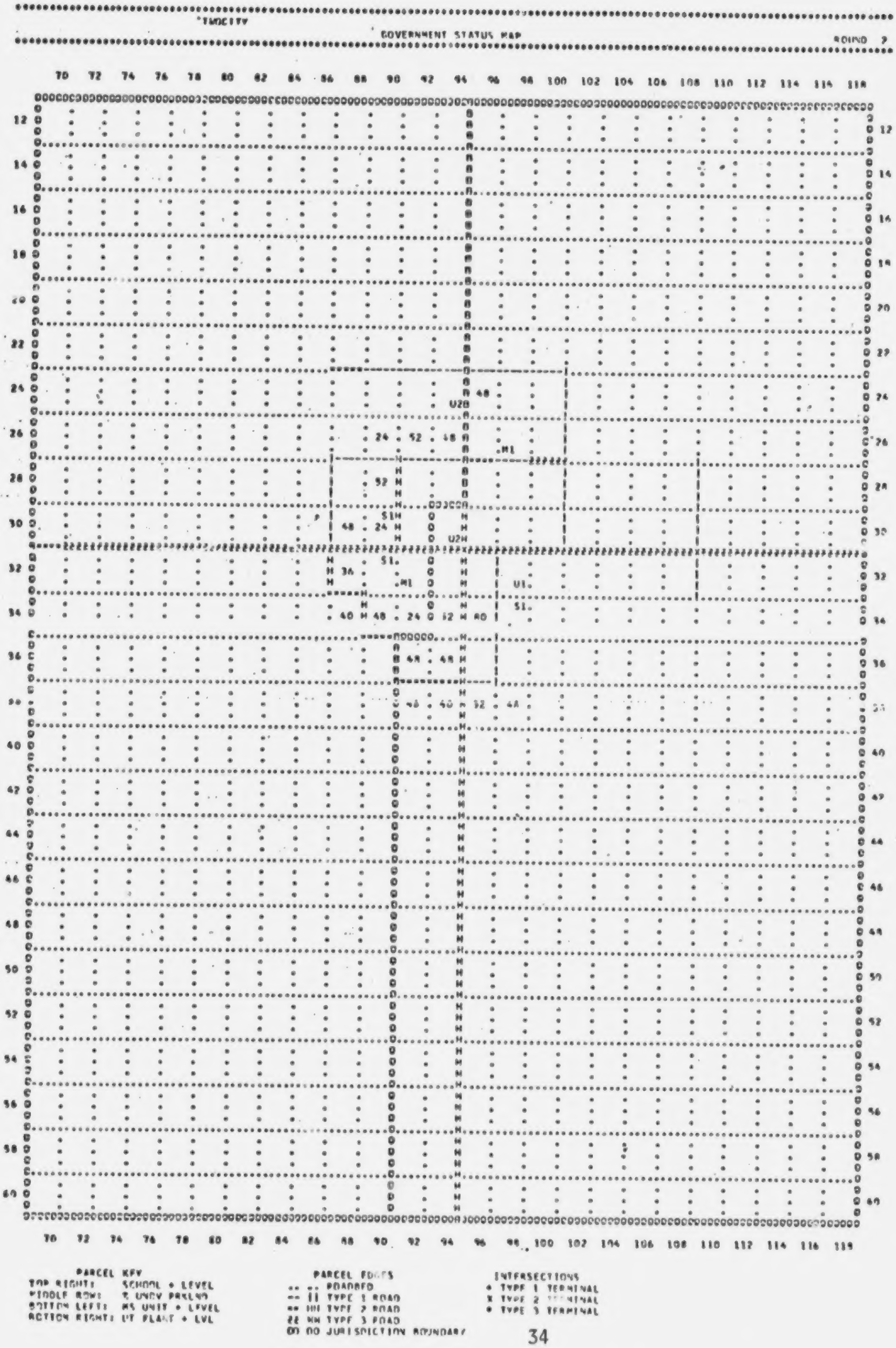
*A road requires land from the parcels on each side, and a terminal requires land from the four parcels touching the intersection at which it is located.

Figure 10.26


TWOCITY
GOVERNMENT STATUS MAP
ROUND 7
PARCEL KEY
TOP RIGHT: SCHOOL + LEVEL
MIDDLE ROW: % UNCV PRKLND
BOTTOM LEFT: MS UNIT + LEVEL
BOTTOM RIGHT: UT PLANT + LVL
PARCEL EDGES
.. .. ROADBED
-- || TYPE 1 ROAD
== ||| TYPE 2 ROAD
ZZ HH TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

3. Socio-Economic Distribution Map

This map shows the number of Pl's of each class living on each residence parcel. The residence type and level are also printed.

The migration process allocates people to housing. Only two classes can live on a residence parcel simultaneously, due in part to the model's restriction that a PH will not move into a residence with a quality index below 71 and a PL will not move into housing with a quality index above 70. It is possible, if a residence depreciates below the minimum that a class will accept, that high-income, for example, will live in a residence with a quality index below 71 if the class was living on the parcel before the depreciation. In no case, however, can PH's reside on the same parcel with PL's.

Each level of a residence type provides a fixed number of space units. A Pl occupies a fixed number of space units, depending on its class. The percent occupancy of each residence is shown on the Demographic Map.

Figure 10.22

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TWOCITY
                    SOCIO-ECONOMIC DISTRIBUTION MAP                    ROUND 7
```
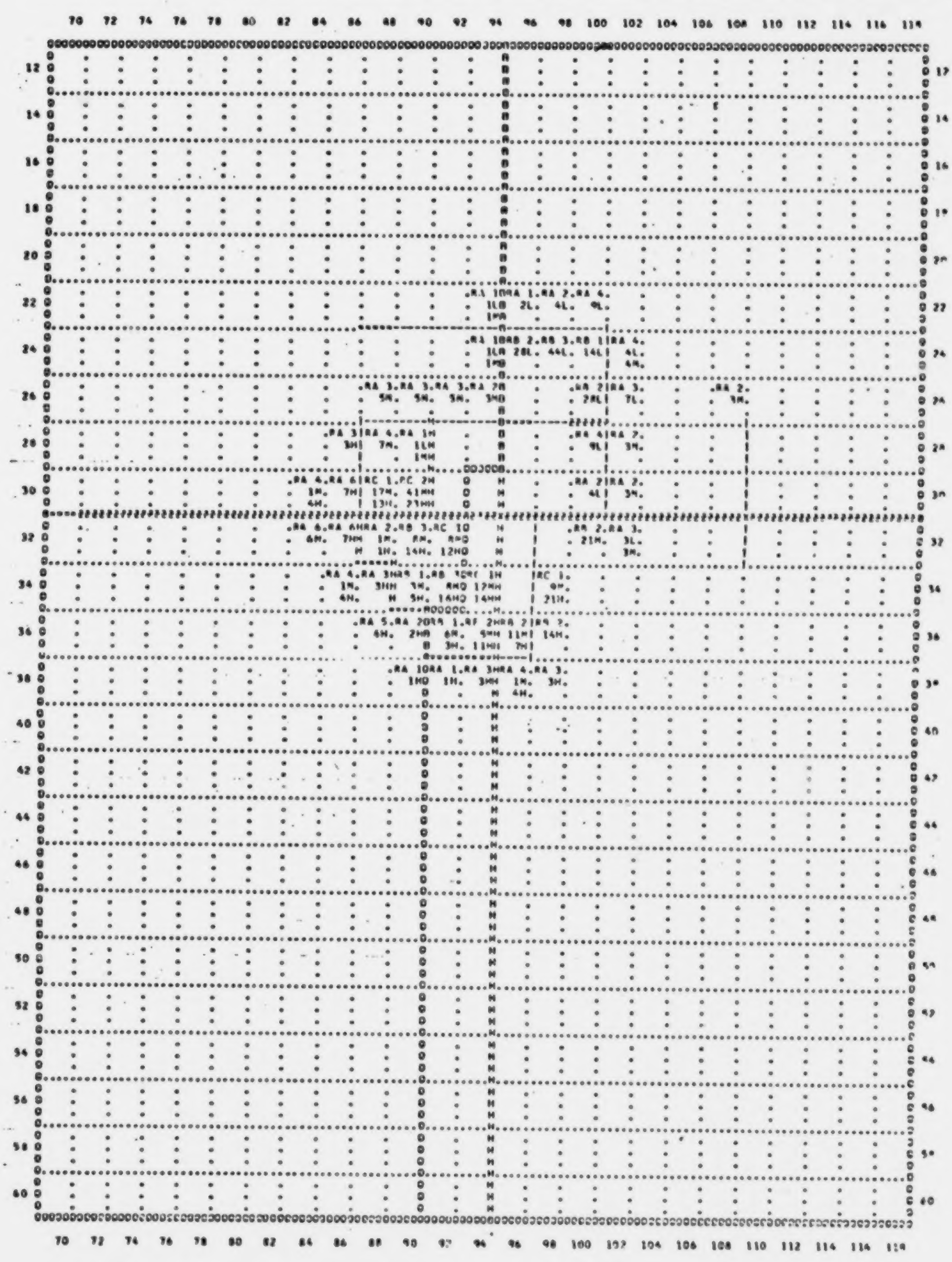


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

```
        PARCEL KEY                          PARCEL EDGES                  INTERSECTIONS
TOP ROWS     RESIDENCE TYPE AND LEVEL   .. .. ROADBED                   + TYPE 1 TERMINAL
MIDDLE ROWS NUMBER OF PI'S AND CLASS    -- || TYPE 1 ROAD               X TYPE 2 TERMINAL
BOTTOM ROWS NUMBER OF PI'S AND CLASS    == HH TYPE 2 ROAD               # TYPE 3 TERMINAL
                                        ## HH TYPE 3 ROAD
                                        OO OO JURISDICTION BOUNDARY
```

4. Demographic Map

The demographic map shows the number of people living on each residence parcel, the percent occupancy of each residence and the quality of all privately owned buildings and equipment.

Overcrowding (over 100% occupancy) contributes to a residence's neighborhood index and to the health index.

The quality is expressed as the quality index for a residence and as the value ratio for non-residential activities. A value ratio is the ratio of the present condition of a business' buildings and equipment to their original condition, expressed as a percent.

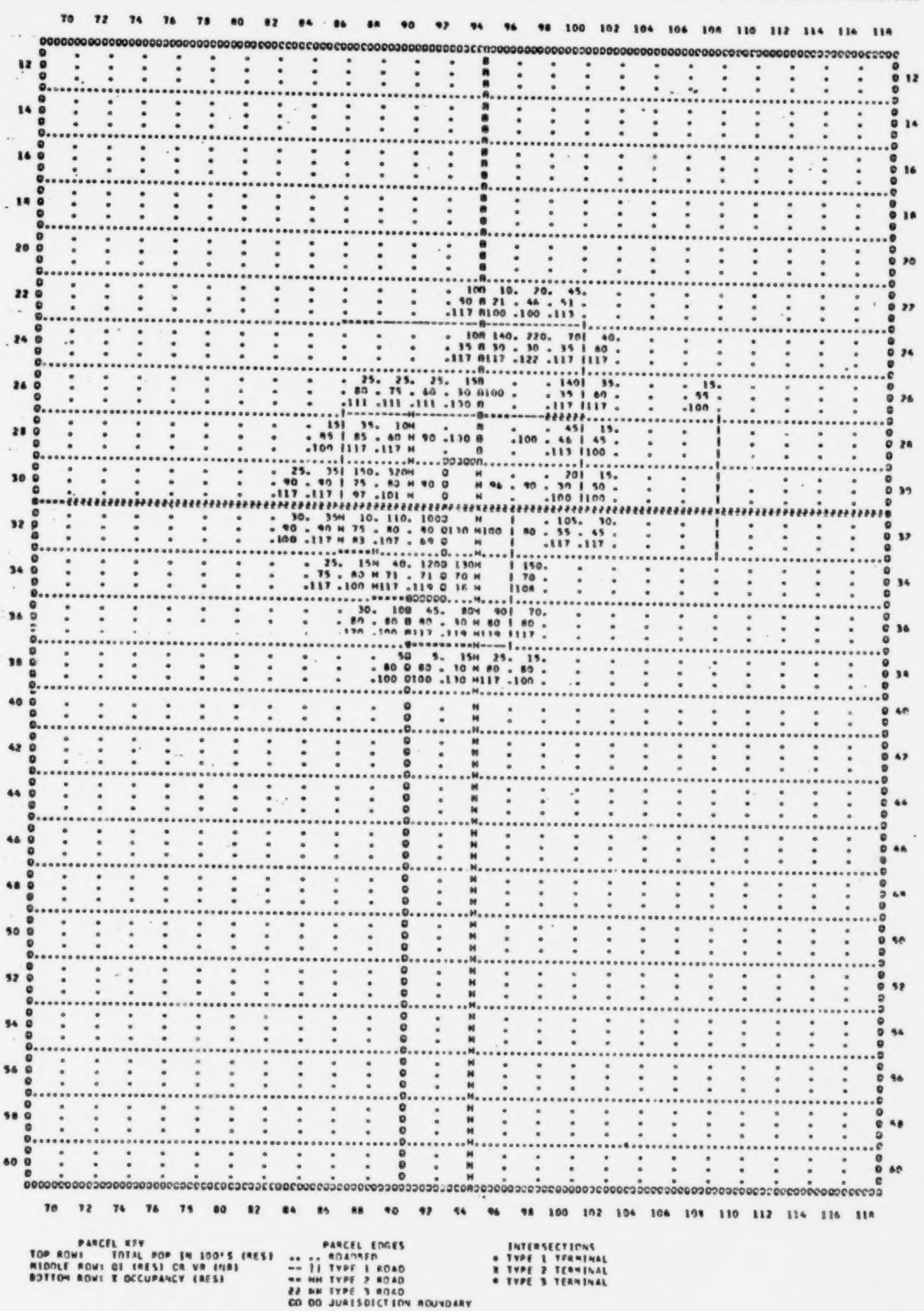
A quality index is somewhat different. Whereas a new business has a value ratio of 100, a new residence can have a quality index from 40 to 100.

Each year buildings and equipment depreciate in response to several conditions which vary by type of activity (see the Master Tables for the causes of depreciation). A business's depreciation is measured as a percent of original value (100). A residence's depreciation is measured as a percent of the original value of such a type of residence originally built at a quality index of 100, regardless of the original quality of the specific residence. Thus, business depreciation is a percent of original value but residential depreciation is a percent of quality index 100.

The owner of an activity can set a maintenance level for the activity. The maintenance level is the quality index or value ratio at which the owner will maintain the activity, regardless of how much it depreciates in a year. Not until the activity's value ratio or quality index falls to its maintenance level does the owner incur maintenance expenditures. The computer program depreciates and maintains buildings and equipment and charges the owner for the maintenance cost.

The Demographic Map shows quality indexes and value ratios after depreciation and after any maintenance.

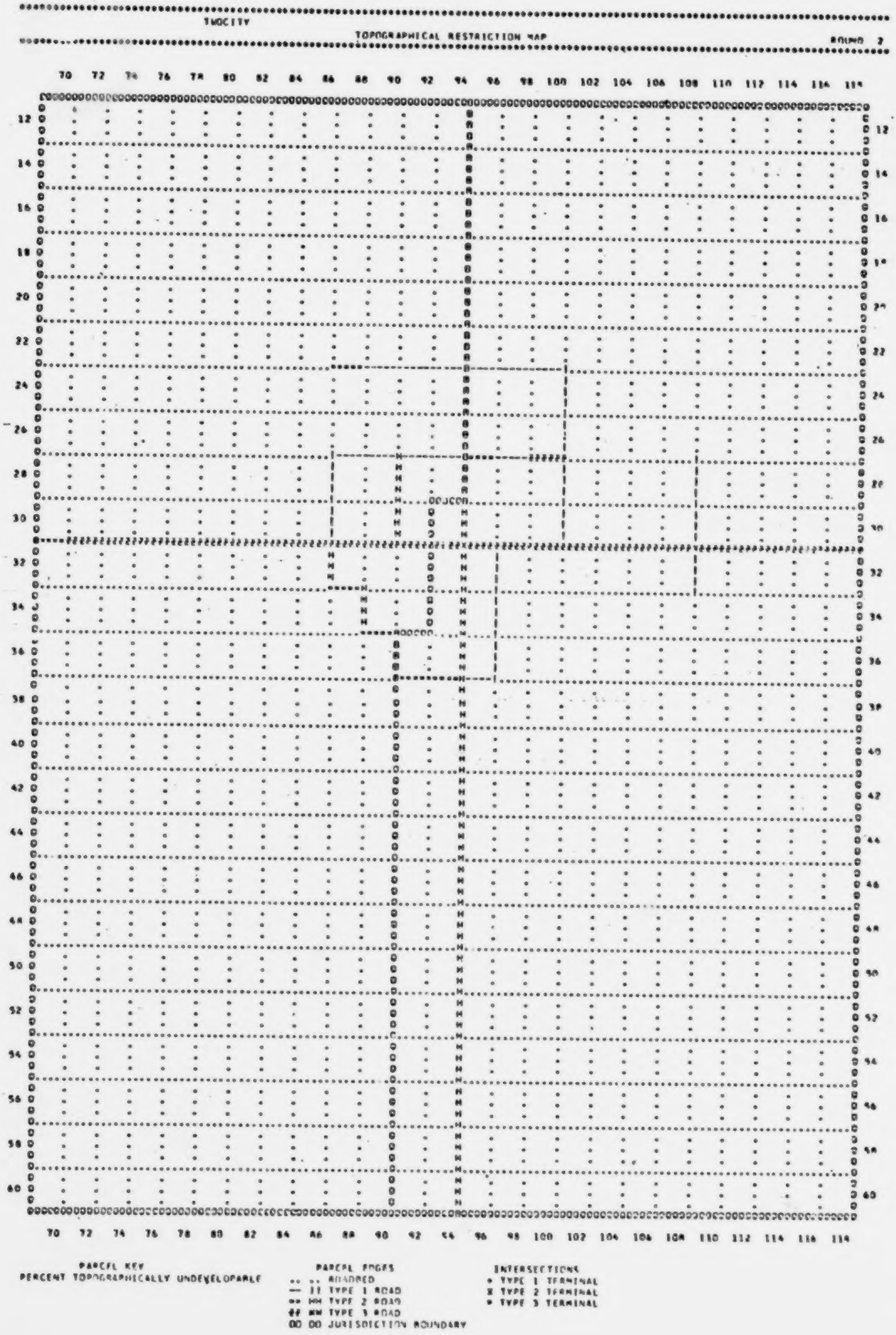
Figure 10.23


TWNCITY
DEMOGRAPHIC MAP
ROUND 2
PARCEL KEY
TOP ROW: TOTAL POP IN 100'S (RES)
MIDDLE ROW: GI (RES) CR VR (NR)
BOTTOM ROW: % OCCUPANCY (RES)
PARCEL EDGES
.. .. ROADBED
-- || TYPE 1 ROAD
== HH TYPE 2 ROAD
22 NN TYPE 3 ROAD
CO OO JURISDICTION BOUNDARY
INTERSECTIONS
• TYPE 1 TERMINAL
X TYPE 2 TERMINAL
• TYPE 3 TERMINAL

5. Topographical Restriction Map

This map shows the percent of a parcel that may not be purchased or developed by any local decision-makers. Land that is topographically undevelopable includes mountains, rock outcrops, swamps. None of the area consumed by water bodies represented in the local system (large lakes, small lakes, and rivers) is shown on this map. The map also shows jurisdictional boundaries, the road network, and the location of terminals.

Figure 10.25

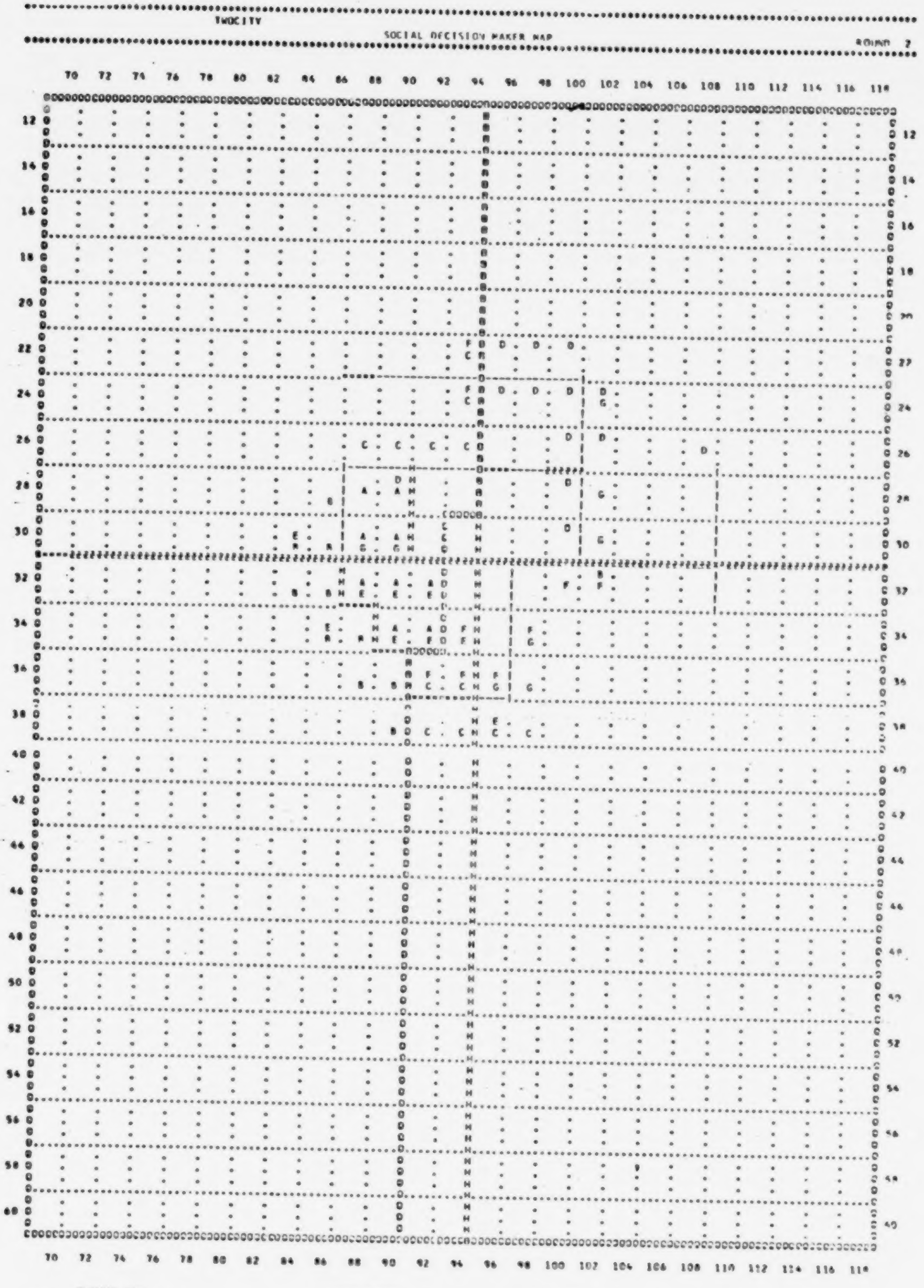

TWOCITY
TOPOGRAPHICAL RESTRICTION MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCEL KEY
PERCENT TOPOGRAPHICALLY UNDEVELOPABLE
PARCEL EDGES
.. .. ROADED
— II TYPE 1 ROAD
== HH TYPE 2 ROAD
## MM TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

6. Social Decision Maker Map

This map indicates which social players make decisions for the low, middle, and high income population units on parcels. The top letter on a given parcel represents the social decision-maker who controls the PL's who live there, and the middle and lower letters represent the social decision-makers who control the PM's and PH's, respectively, who live there. If a particular class does not live on a parcel, no letter is printed.

Not until a parcel is developed for residential land use and occupied by at least one income class, will a social decision-maker for that parcel appear on the map. Note that different decision-makers may control the different population classes on a single parcel. Social teams acquire control over additional Pl's on a parcel when the number of Pl's of that class moving into the parcel exceeds the number moving out. Social teams may find that from round to round they gain or lose control of population units on a residential parcel of land. This occurs as a result of the migration of Pl's of a class to a parcel where previously there were no Pl's of that class (a gain) or as a result of the migration away from a parcel of all the Pl's of a class on that parcel.

Figure 10.24


TWOCITY
SOCIAL DECISION MAKER MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

PARCEL KEY
TOP ROW: LOW SOC D-M
MIDDLE ROW: MID SOC D-M
BOTTOM ROW: HI SOC D-M

PARCEL EDGES
.. .. ROADED
-- II TYPE 1 ROAD
== ## TYPE 2 ROAD
HH TYPE 3 ROAD
CO OO JURISDICTION BOUNDARY

INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

7. Utility Map

This map designates the jurisdictional boundaries (000) and the district boundaries (xxx) for all utility plants within each jurisdiction. Utility districts are groups of contiguous parcels that are within the service area of a utility plant. There may be parcels of land that are not contained within a utility district.

The information contained on a land parcel shows the number of utility units required by utility users, the number of utility units installed on the parcel, and the number of the utility district serving the parcel.

Utility plant locations are indicated on the Utility Map with asterisks surrounding the parcels on which the plants are located. Each utility district is identified with a unique utility number (starting with "1" and ending with "n", where "n" is the number of utility districts). The bottom piece of information on each parcel indicates the number of the utility plant serving that parcel.

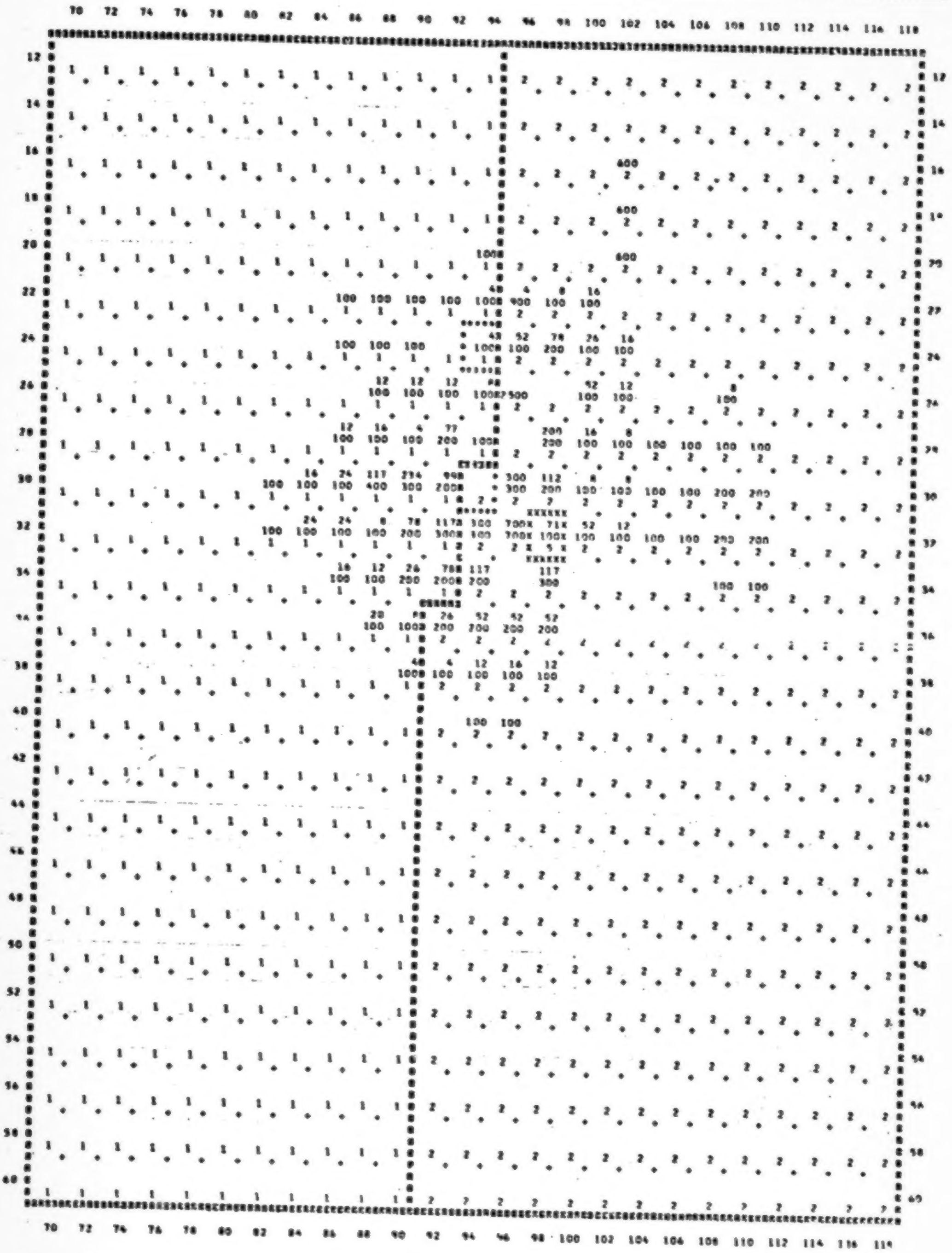
The number of utility units consumed on a parcel is dependent upon the private land use activity. The map key shows the number of utility units demanded by a level one of each of the private land use activities.

The number of units installed on a parcel is a policy decision made by the Utility Department. The Utility Department provides one of nine levels of utility service to a parcel. Each level of utility service has a corresponding number of utility units that may be provided. Consult the Utility Master Table for the maximum number of utility units that may be provided for each level of utility service.

A parcel of land that is within a utility district may not be developed if the private development would require more units of utility service than could be provided by the present level of utility service provided to that parcel. Thus, the "UNITS INSTALLED" puts an upper limit on the "UNITS SERVED" for all parcels within utility districts.

Figure 10.6

```
TWOCITY
                                   UTILITY MAP
                                                                        ROUND 2
```



```
      PARCELS                                   PARCEL EDGES
TOP ROW:    UNITS SERVED                   XX DISTRICT BOUNDARY
MIDDLE ROW: UNITS INSTALLED                OO JURISDICTION BOUNDARY
BOTTOM ROW: UTILITY CODE IF UT ON PARCEL   BB BOTH
                                           ** UT ON PARCEL

                                                  UNITS REQUIRED     UNITS REQUIRED
                                                  BASIC INDUSTRY       COMMERCIAL
                                                    HI1  402            RC1  112
                                                    LI1  135            RS1   71
                                                    NS1   76            PC1   99
                                                  RESIDENCES            PS1   77
                                                    RA1    4           CONSTRUCTION
                                                    RB1   26            CI1  NONE
                                                    RC1  117
```

8. Surface Water Map

The Surface Water Map displays those characteristics of a surface water system which do not change dynamically during a particular run of the model. For each parcel on which there is surface water, the map shows the volume of water, its rate of flow, and the percent of the surface area of the parcel which is water.

The volume of water on a parcel is measured in millions of gallons per day (MGD) passing any one point on the parcel. The volume of water on a parcel affects both the water quality on a parcel and the amount of water which can be removed from the surface water on that parcel for municipal and industrial use.

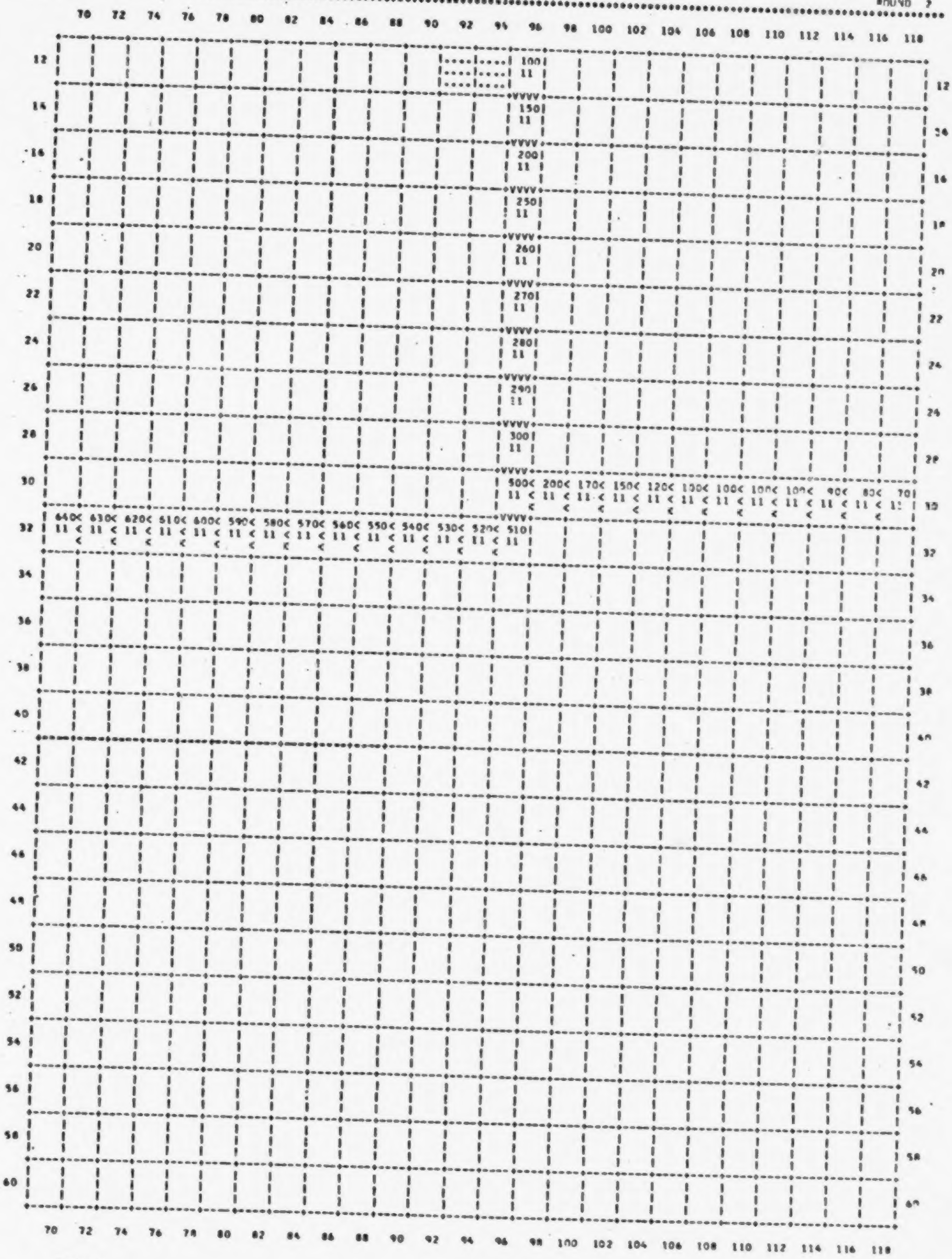
The rate of flow of water on a parcel is measured in the number of parcels which water flowing at that rate would cross in one day. Water bodies undergo a natural cleansing process. The slower a river flows, the less distance some types of pollutants travel before they are naturally removed from the river.

The amount of surface area occupied by water has one effect in the model: it preempts a portion of the parcel from use in other activities.

The map also displays the direction of the river's flow. The arrows between parcels point in the direction that the water flows. Water flows from parcel to parcel, traveling within parcels. If a parcel has a volume of water but no arrows pointing away from it, it either is the last parcel through which a river flows or has a self-contained surface water system which does not dynamically interact with the other surface water system parcels.

A parcel which is displayed as all dots is entirely water, usually a very large body of water into which a river flows, such as a large lake or ocean. The water on such a parcel does not interact with the surface water represented in the model; its quality is affected by activities in an area much greater than the simulated area. For convenience, such a water body is termed a lake in the model.

```
                         TWOCITY
                    SURFACE WATER MAP
                                                                                              ROUND 2
```



70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
100
11
VVVV
150
11
200
11
250
11
260
11
270
11
280
11
290
11
300
11
500< 200< 170< 150< 120< 100< 100< 100< 100< 90< 80< 70
11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11
640< 630< 620< 610< 600< 590< 580< 570< 560< 550< 540< 530< 520< 510
11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11

```
PARCELS
-------
   TOP ROW: AMOUNT OF SURFACE WATER
            ON PARCEL  (MGD)
MIDDLE ROW: RATE OF FLOW
BOTTOM ROW: PERCENT OF SURFACE AREA
            OF PARCEL IN WATER
....
....  LAKE PARCELS
....

PARCEL EDGES
------------
>AV<  DIRECTION OF FLOW
----  NO WATER FLOWING
      BETWEEN PARCELS
```

9. Municipal Treatment Plant Map

A Utility Department supplies water to all economic activities except some basic industries which obtain their own water from the surface water. Each utility district is also a water district. A parcel is supplied with municipal water and sewer service when utilities are installed on the parcel. The department can decide where to intake water, where to dump sewage, how much intake water it will provide, how much sewage treatment it will provide, and where treatment facilities will be located.

Municipal water intake and sewage treatment plants are located in the utility districts which they serve. An intake treatment plant processes the surface water removed from the parcel on which its intake point is located (not necessarily within the water district which it serves). All water treated by an intake treatment plant is processed to drinking water quality. The quality of the water before it is treated varies with the amount of pollution in the surface water where the intake point is located. There are nine water quality ratings, 1 being the best quality and 9 being the worst. A parcel's water quality rating is based on the volume of water on the parcel and the amount of pollution entering it from adjoining parcels.

Water Quality Rating	Description
1	Drinkable - best quality water
2	Drinkable - with minor treatment
3	Swimmable - direct body contact possible
4	Boating and Fishing - indirect body contact
5	Fair esthetic value
6	Poor esthetic value - treatable at moderate cost
7	No esthetic value - treatable at high cost
8	Negative esthetic value - treatable at very high cost
9	Unusable water

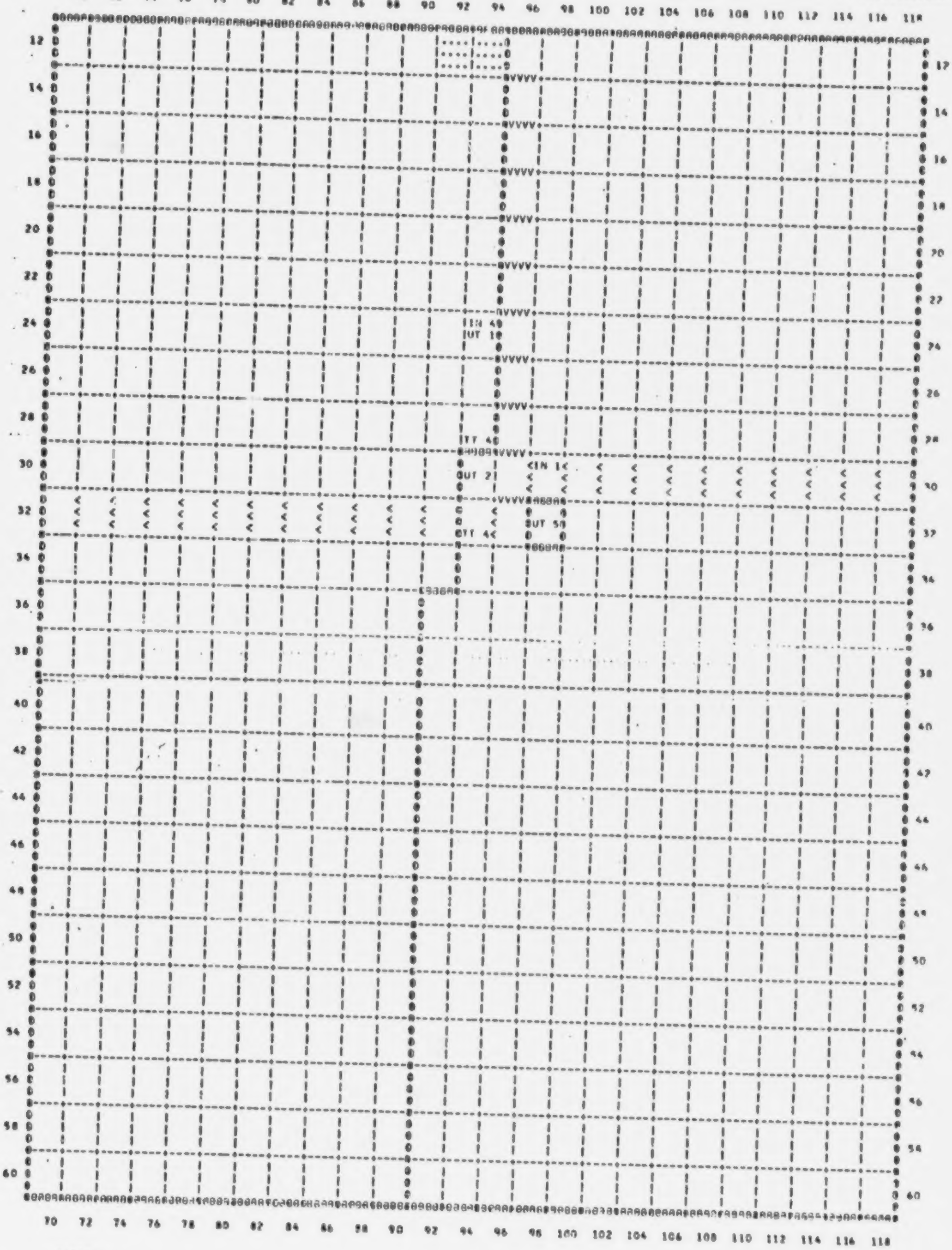
Seven types of pollutants are measured for the quality rating.

Pollutants	Description
BOD	Biochemical Oxygen Demand; the

Figure 10.9

TWOCITY
MUNICIPAL TREATMENT PLANTS

ROUND 2


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
IN 40
UT 10
TT 40
OUT 2
IN 1
OUT 50
TT 4

PARCELS

TOP LEFT: IN FOR MUNICIPAL [illegible] TREATMENT PLANT
TOP RIGHT: LEVEL OF INTAKE TREATMENT PLANT
MIDDLE LEFT: OUT FOR UTILITY DISTRICT PLANT
MIDDLE RIGHT: CODE NUMBER OF UTILITY DISTRICT
BOTTOM ROW: MUNICIPAL EFFLUENT TREATMENT TYPE AND LEVEL

....	LAKE PARCELS

PARCEL EDGES

>AV<	DIRECTION OF FLOW
----	NO WATER FLOWING BETWEEN PARCELS
0000	UTILITY DISTRICT BOUNDARY

Pollutants	Description
	natural breakdown of this pollutant causes a decrease in the concentration of dissolved oxygen in the water.
Chlorides	Chlorides are employed as an indicator of persistent pollutants.
Nutrients	Phosphate, nitrite, nitrate, nitrogen, and phosphorous.
Coliform Bacteria	Indication of the potential health hazard of a given body of water.
Temperature	A measure of the deviation from the normal temperature of the surface water.
Oil and Floating Solids	Any oil added to the system and all floating solids such as refuse, garbage, cans, boards, tires, etc.
High-Level Wastes	Highly toxic, non-degradable substances.

The quality of water at a district's intake point affects, among other things, the cost to process the water to drinking water quality. The water quality of a parcel is shown on the Water Quality Map. That quality is not affected by any pollution dumped on the parcel, only by pollution dumped on upstream parcels.

An inflow treatment plant, while able to make all but the worst (quality 9) water drinkable, has a capacity which is a function of its level. The amount of water which a district needs is a function of the needs of the activities located in the district, but the amount of water which a district can obtain may be limited by its inflow treatment plant capacity. Whenever a district cannot obtain all of its needed water for any reason, including insufficient inflow treatment plant capacity, the activities served by the district purchase that proportion of their water needs which cannot be met locally from the Outside at a high cost. The cost to construct an inflow treatment plant increases with the number of levels constructed. Unlike levels of other activities in the model, municipal treatment plant costs and capacities are not necessarily even multiples of level one costs and capacities. The land requirements, however, are multiples of level one.

Municipal sewage treatment plants can be constructed not only to different levels (capacities) but also to different types of treatment. The types of sewage treatment are, in increasing order of pollution removal:

Chlorination (CL)
Primary Treatment (PT)
Secondary Treatment (ST)
Tertiary Treatment (TT)

Tertiary treatment requires the three other types of treatment; secondary treatment requires chlorination and primary treatment. The level of treatment printed on the map is the level of the type printed and of all lesser types. There is no provision for the case of different levels of different types of treatment within a single district.

Since treatment plants have fixed capacities which vary by their levels, any district's sewage in excess of its plant's capacity flows untreated into the surface water on the parcel on which the district's outflow point is located.

Note that all of a district's intake treatment must be located on a single parcel. Likewise, all of its sewage treatment must be on a single parcel, although that parcel does not have to be the same one as that on which its intake treatment plant is located.

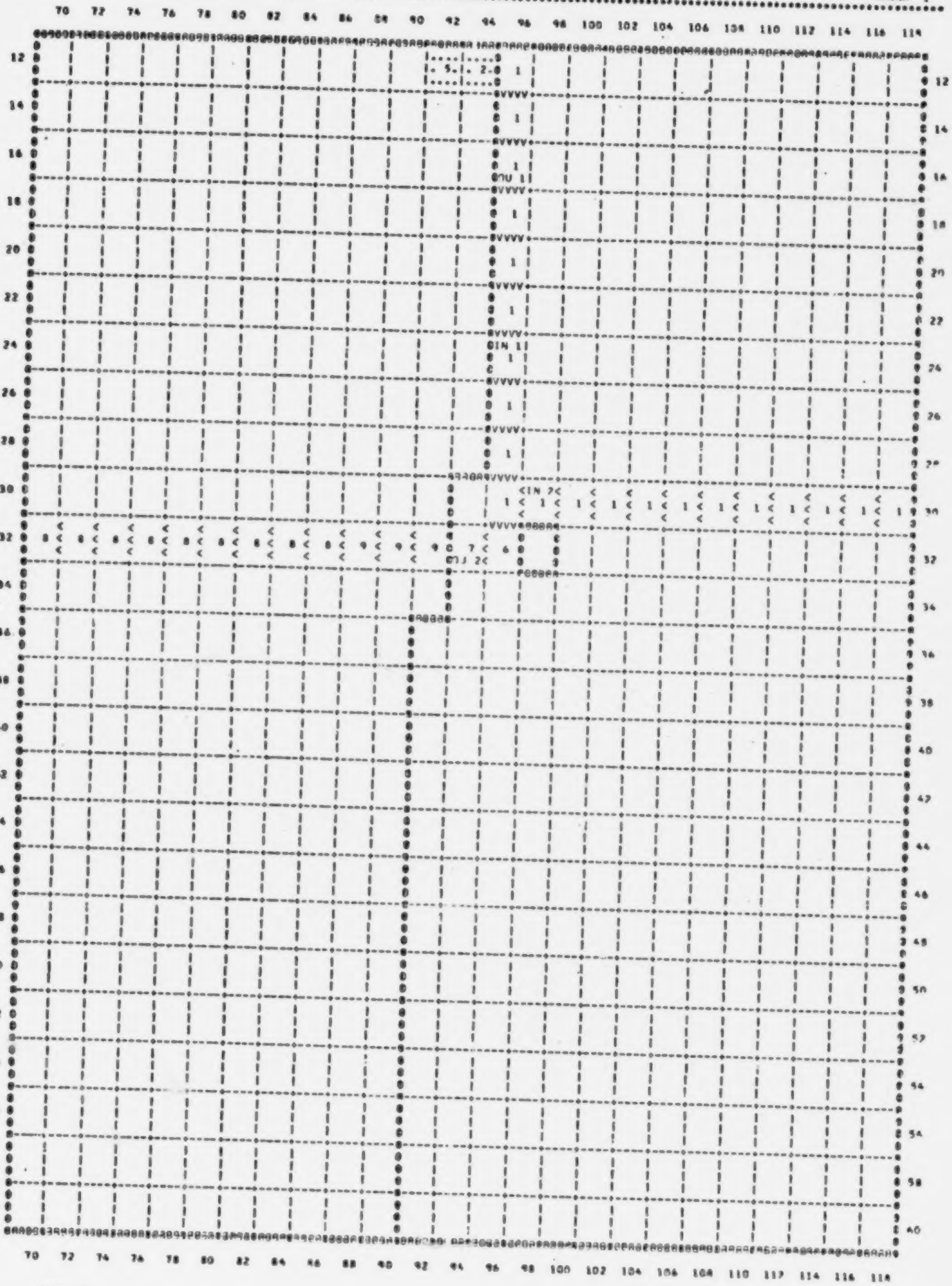
'UT' appears in the middle row of a parcel if there is a utility plant on the parcel. Next to the 'UT' is the code number of the utility plant. That number matches the number printed next to the district's intake and outflow points on the Municipal Inflow and Outflow Point Map.

10. Municipal Inflow and Outflow Point Map

Unlike treatment plants, municipal intake and outflow points do not have to be located within the districts which they serve. This map shows where each district's intake and outflow points are located. The code number next to the 'IN' or 'OU' on the map is the code number of the utility plant in the district which the point serves.

Each district has one intake point and one outflow point. However, there can be more than one inflow and outflow point on a parcel. The map shows only one point, so if there is nore than one on a parcel, only the Utility Department Report will note the existence of all of the others.

```
TWOCITY
MUNICIPAL INFLOW AND OUTFLOW POINTS
                                                                    ROUND  7
```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32
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36
38
40
42
44
46
48
50
52
54
56
58
60
5
2
1
OU 1
IN 1
IN 2
IN 2
8
9
7
6
OU 2

```
PARCELS
-------
TOP LEFT: IN FOR MUNICIPAL INFLOW POINT
TOP RIGHT: CODE NUMBER OF UTILITY DISTRICT INTAKING
MIDDLE ROW: SURFACE WATER QUALITY RATING
BOTTOM LEFT: OU FOR OUTFLOW POINT
BOTTOM RIGHT: CODE NUMBER OF UTILITY DISTRICT DISCHARGING

PARCEL EDGES
------------
>AV<  DIRECTION OF FLOW
----  NO WATER FLOWING
      BETWEEN PARCELS
0000  UTILITY DISTRICT BOUNDARY

....
....  LAKE PARCELS
....
```

11. Water Quality Map

The surface water quality on a parcel is a function of the pollution entering the parcel from adjoining parcels and of the amount of water on the parcel itself. The water quality on a parcel is not affected by any dumping activity on the parcel itself. Any activity which removes water from a parcel removes it at the quality shown on the Water Quality Map.

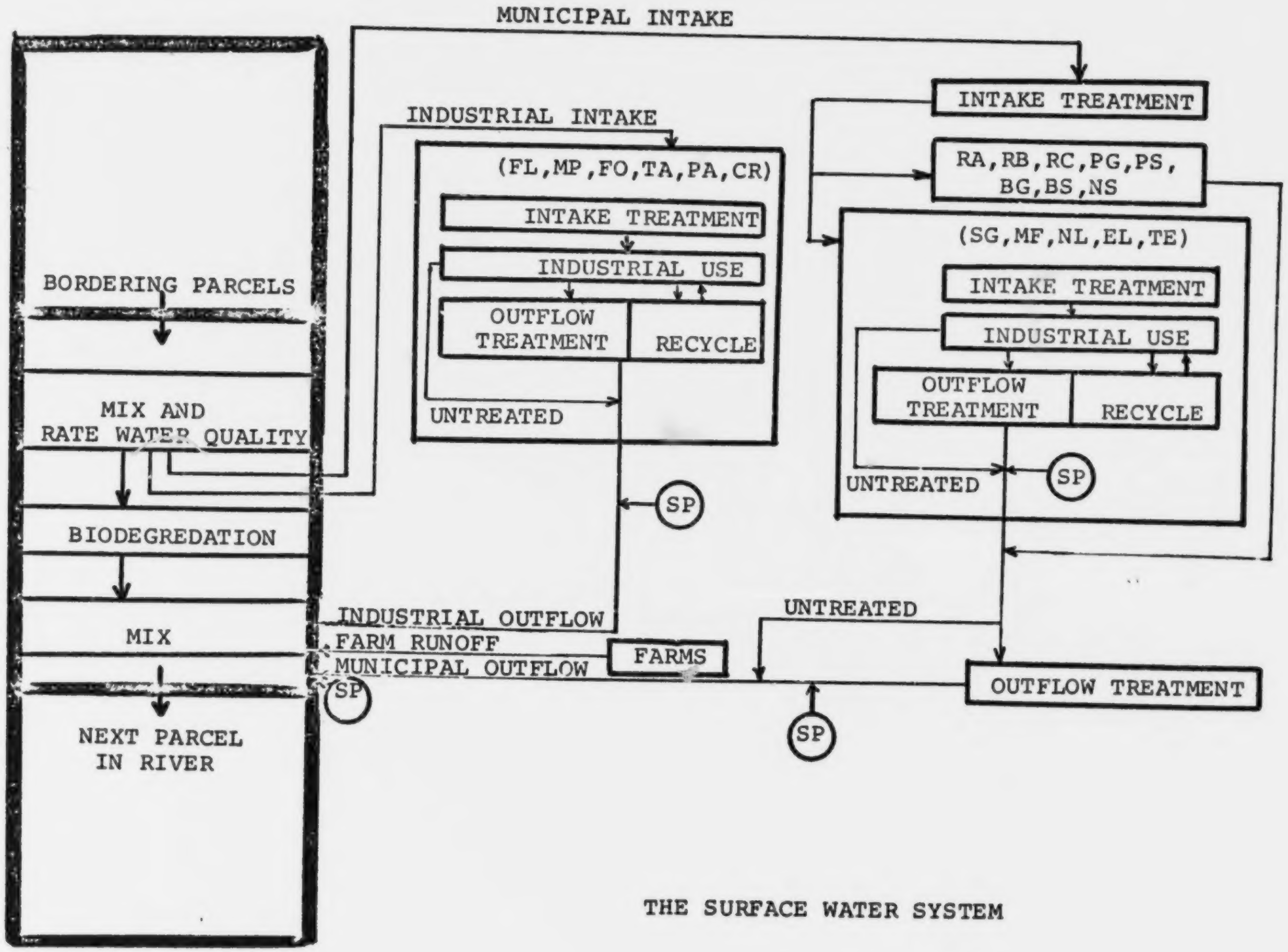
Quality is the only characteristic of surface water which can change during a run of the model. The other characteristics (rate of flow, volume, and surface area) are constant.

Water Sampling Stations can be set up to measure the exact pollution content of the water flowing out of parcels. Sampling stations can also be established to measure the pollution content of water generated by either individual economic activities or municipal systems. The operation of a sampling station is charged to the Utility Department of the jurisdiction in which the station is located.

The figure on the next page illustrates the processes which affect surface water pollution. The pollution flowing into a parcel from adjoining parcels is mixed in the water on the parcel. The pollution concentration per MGD is then measured and the water is rated in one of the nine water quality categories. The water quality rating is the worst rating category generated in any single pollutant. The rating allows no trade-off between a pollutant which is present in very low concentration and one which is very highly concentrated.

Next, water is removed if there are any intaking activities on the parcel. There are two types of intaking activities: 1) basic industries of the types which require surface water; and 2) municipal intake points. There can be only one economic activity on a parcel, and if it is a surface water user, it intakes and dumps on the parcel on which it is located. Municipal intake water is sent to the municipal intake treatment plant and from there to activities served by the district.

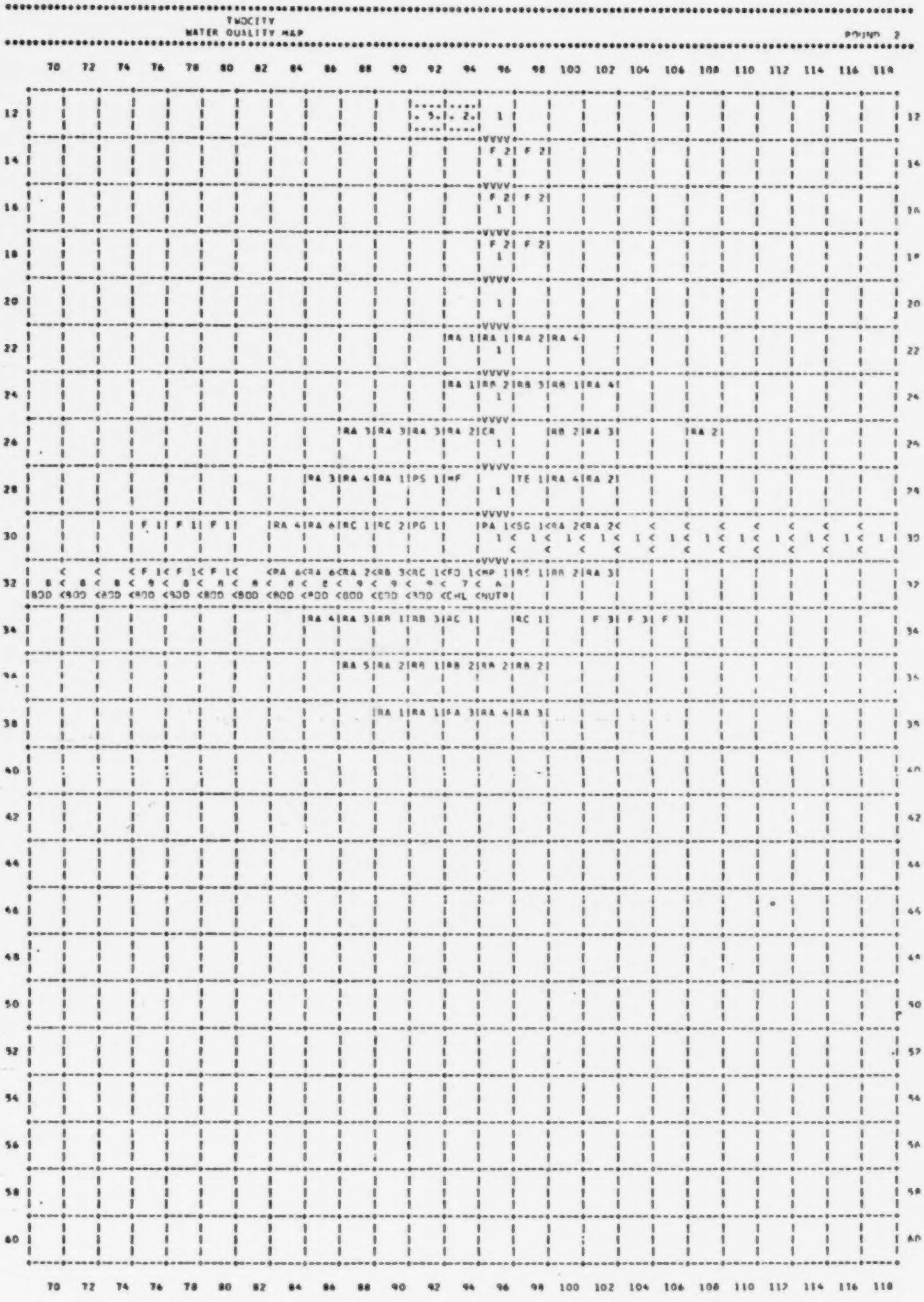
The surface water which is not removed undergoes a biological change process in which some of the pollutants decay naturally. That water is mixed with any water dumped on the parcel. There are three types of activities which can dump on a parcel. In addition to basic industries


MUNICIPAL INTAKE
INDUSTRIAL INTAKE
BORDERING PARCELS
MIX AND RATE WATER QUALITY
BIODEGREDATION
MIX
NEXT PARCEL IN RIVER
(FL,MP,FO,TA,PA,CR)
INTAKE TREATMENT
INDUSTRIAL USE
OUTFLOW TREATMENT
RECYCLE
UNTREATED
SP
INDUSTRIAL OUTFLOW
FARM RUNOFF
MUNICIPAL OUTFLOW
FARMS
SP
SP
INTAKE TREATMENT
RA,RB,RC,PG,PS, BG,BS,NS
(SG,MF,NL,EL,TE)
INTAKE TREATMENT
INDUSTRIAL USE
OUTFLOW TREATMENT
RECYCLE
UNTREATED
SP
UNTREATED
OUTFLOW TREATMENT

THE SURFACE WATER SYSTEM

(SP) = Sampling Point Possible

Figure 10.8


TWOCITY
WATER QUALITY MAP
ROUND 2

PARCELS

TOP ROW: ECONOMIC ACTIVITY TYPE
AND OPERATING LEVEL
FARM TYPE IF FARM ON PARCEL
MIDDLE ROW: SURFACE WATER QUALITY RATING
BOTTOM ROW: WORST POLLUTANT

....
.... LAKE PARCELS
....

PARCEL EDGES

>^V< DIRECTION OF FLOW

---- NO WATER FLOWING
BETWEEN PARCELS

and municipal outflow points, farm runoff can add to the pollution on a parcel. Whereas basic industries and municipalities can treat their effluent and thus remove some or all of their pollution, farm pollution can be cut back only if the farm owner decreases the amount of fertilizer used on the farm. The total amount of pollution is then moved on to the next parcel in the river.

The water quality map shows where rivers and economic activities are located in addition to water quality.

12. Water Usage Map

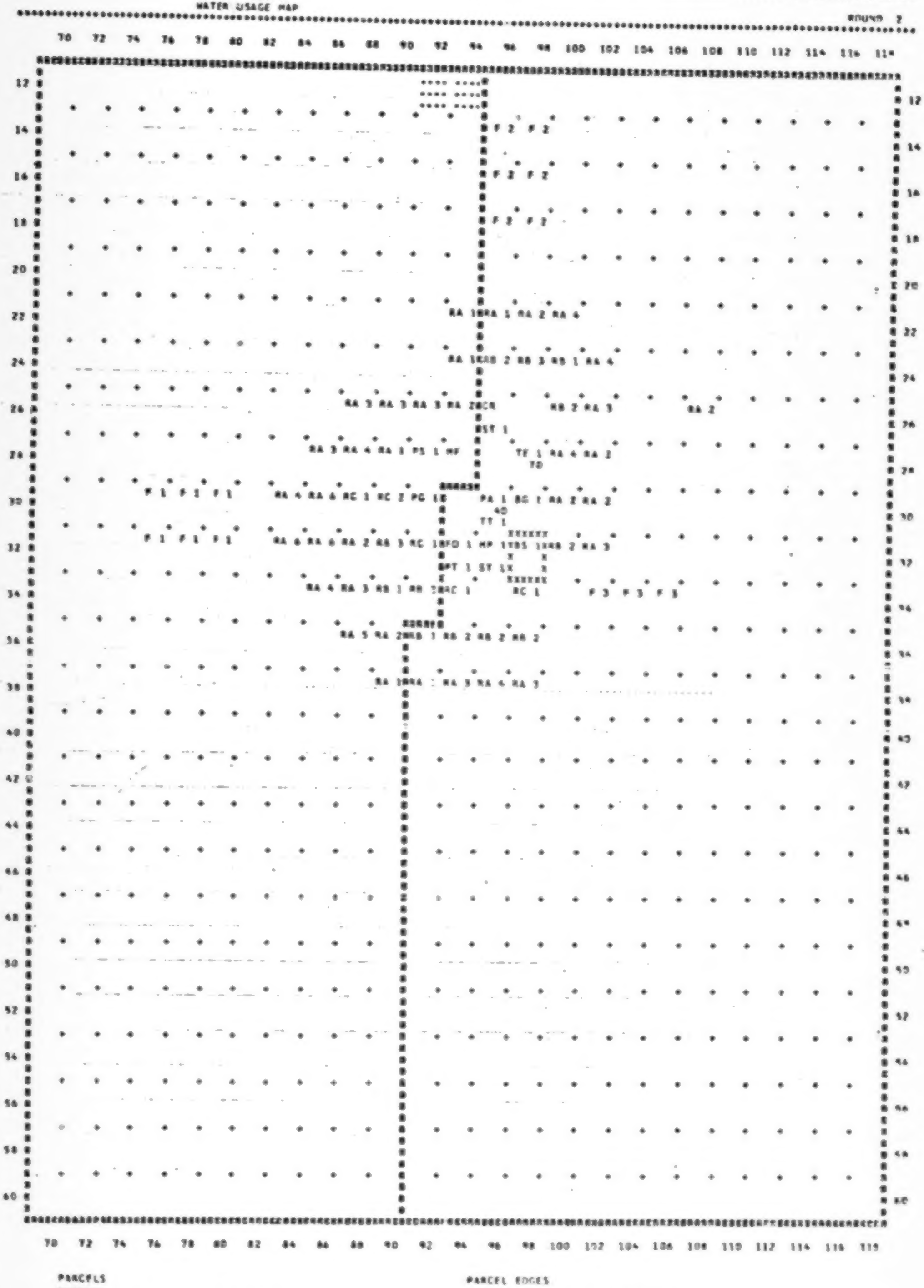
Basic industries can treat their effluent in order to remove pollutants. An industry's effluent treatment plant is located on the same parcel as the industry and does not consume land. Like municipal effluent treatment plants, industrial treatment plants can be of four types: chlorination (CL), primary treatment (PT), secondary treatment (ST), and tertiary treatment (TT). Industrial treatment plants can be constructed to any level and each treatment plant level has the capacity to treat all of the effluent of a level of the industry type which it is constructed to serve. The construction cost of a level of treatment plant varies by treatment type and type of industry.

Industries can recycle up to half of their effluent. Recycled water is not processed through an effluent treatment plant. Its treatment is a process distinct from industrial intake or outflow treatment and costs a fixed number of dollars per MG recycled. So, a level two industry at a recycle level of 100% and having a level one effluent treatment plant treats all of the water which it dumps. If the recycle level under those conditions were 50%, then the industry would treat only two-thirds of the amount which it dumped and one third would be dumped untreated.

Unlike municipal water intake treatment facilities, industrial intake treatment is assumed to exist when the industry is constructed and it is assumed to have the capacity to treat all of the water required by the industry. Like municipal intake treatment costs, industrial intake treatment costs increase as water quality worsens, and the worst water (quality 9) cannot be treated. The industry is forced to pay a high cost for water, the cost represented by the Outside price of water. Furthermore, intake water quality affects the depreciation of surface water users, a reflection of wear on treatment equipment.

NOTE: Regardless of the amount of recycling, intake water quality has the same effect on industrial depreciation. The volume treated does not matter. The assumption is that recycled water goes through intake treatment, so no wear and tear on treatment equipment has been avoided.

Figure 10.7


TWOCITY
WATER USAGE MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
F 2 F 2
F 2 F 2
F 2 F 2
RA 1 RA 1 RA 2 RA 4
RA 1 RB 2 RB 3 RB 1 RA 4
RA 3 RA 3 RA 3 RA 2 CR
RB 2 RA 3
RA 2
ST 1
RA 3 RA 4 RA 1 PS 1 HF
TF 1 RA 4 RA 2
70
F 1 F 1 F 1
RA 4 RA 6 RC 1 RC 2 PG 1
PA 1 BG 1 RA 2 RA 2
40
TT 1
F 1 F 1 F 1
RA 6 RA 6 RA 2 RB 3 RC 1 FD 1 HP 1 TBS 1 RB 2 RA 3
PT 1 ST 1
RA 4 RA 3 RB 1 RB 3 RC 1
RC 1
F 3 F 3 F 3
RA 5 RA 2 RB 1 RB 2 RB 2 RB 2
RA 1 RA 1 RA 3 RA 4 RA 3

PARCELS

TOP ROW: ECONOMIC ACTIVITY TYPE
AND OPERATING LEVEL
MIDDLE ROW: (FOR BASIC INDUSTRIES)
PERCENT OF WATER RECYCLED
BOTTOM ROW: (FOR BASIC INDUSTRIES)
EFFLUENT TREATMENT
TYPE AND LEVEL

PARCEL EDGES

XX XX UTILITY DISTRICT BOUNDARY
OO OO JURISDICTION BOUNDARY
BOTH

....
.... LAKE PARCELS
....

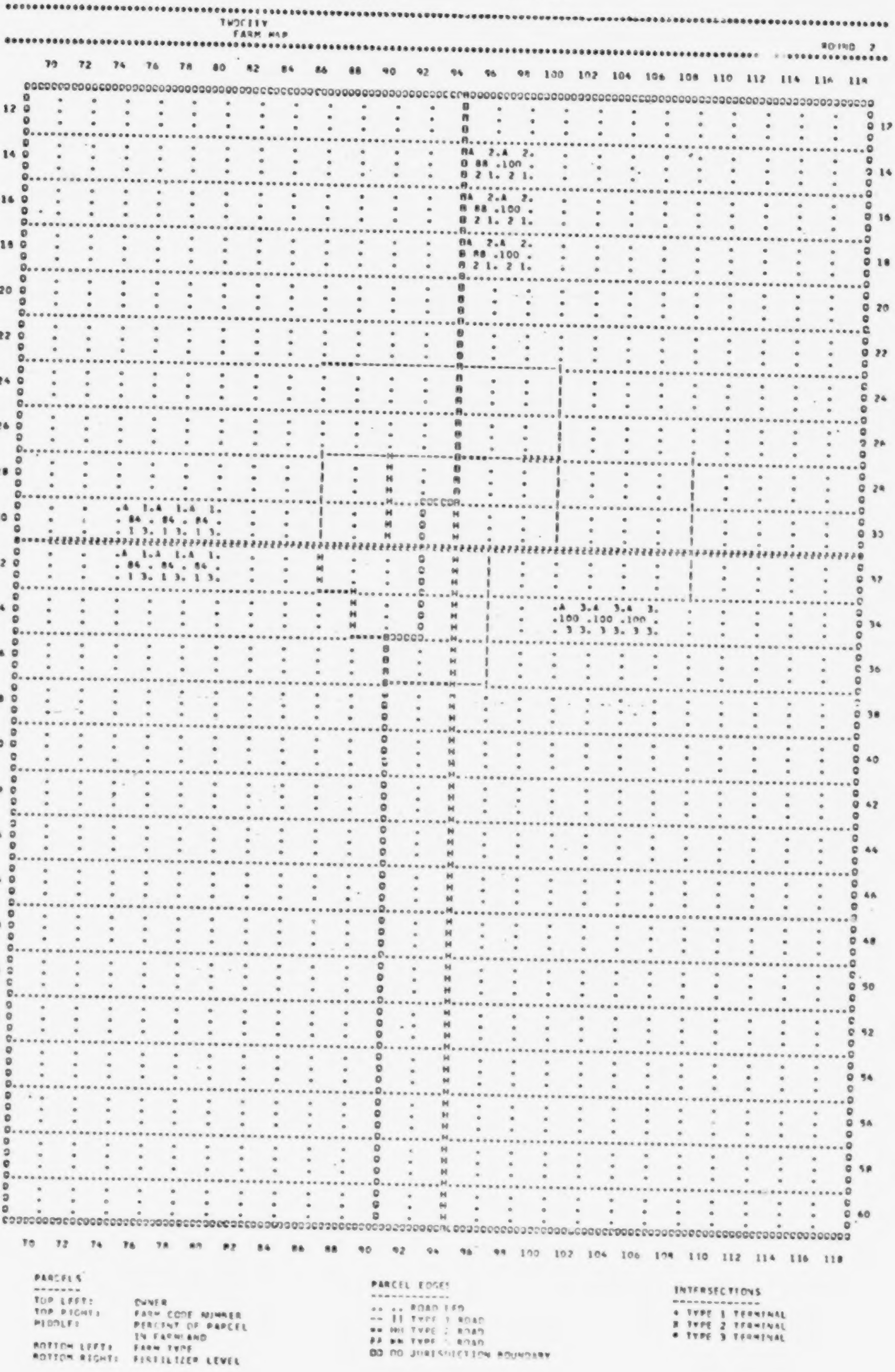
13. Farm Map

A farm can contain more than one parcel. All of the parcels in a single farm have the same owner, farm code number, farm type, and fertilizer level. The amount of land in farm use may be different for the different parcels in a single farm. The rest of the land can be in public use or can be topographically unusable. No other economic activity can be located on a farm parcel, and all of the farmland on a single farm parcel is of the same farm type. When the economic owner of a farm parcel changes, the parcel ceases to be classified as a farm. Once an initial starting configuration of the board has been selected, no farms can be created.

There are two types of decisions which a farm owner can make: set the fertilizer level for a farm; and sell part or all of the farmland on a farm.

A farm's fertilizer level is an integer from 0 to 3. Associated with each of the four fertilizer factors is a multiplierwhich represents the increase in normal income which occurs at that fertilizer factor for the farm type. There is also an associated amount of pollution in the runoff resulting from each fertilizer factor. Volume of runoff stays the same for a farm parcel regardless of the amount of land on that parcel in farm activity. When a parcel is no longer a farm, no more runoff exists. A farm owner's income increases as he sets a higher fertilizer factor level. Likewise, the amount of pollution on a farm's runoff increases with the fertilizer level.

Figure 10.14

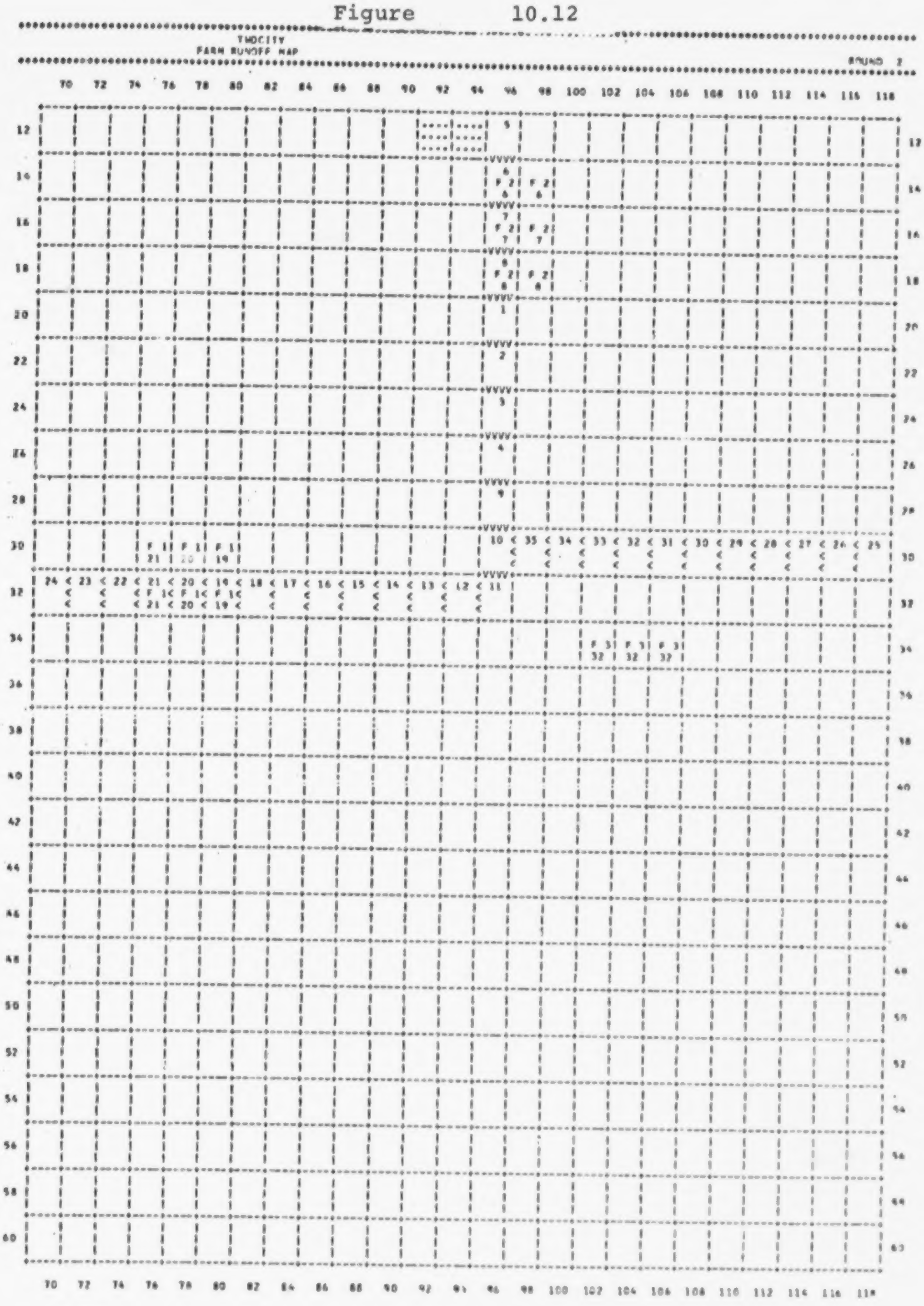

TWOCITY
FARM MAP
ROUND 2
PARCELS
TOP LEFT: OWNER
TOP RIGHT: FARM CODE NUMBER
MIDDLE: PERCENT OF PARCEL IN FARMLAND
BOTTOM LEFT: FARM TYPE
BOTTOM RIGHT: FERTILIZER LEVEL
PARCEL EDGES
.. .. ROAD LED
-- II TYPE 1 ROAD
== HH TYPE 2 ROAD
BB TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
# TYPE 2 TERMINAL
* TYPE 3 TERMINAL

14. Farm Runoff Map

Farms do not use surface water or municipally-supplied water. Their water requirements are assumed to be met by rain or ground water. However, some of the water which falls on farms runs into the surface water. Farms use fertilizer, and those nutrients flow into the surface water in farm runoff. The Farm Runoff Map shows where farm runoff flows. The program assigns each surface water parcel a code number, which is printed on the top row of parcels containing surface water. Wherever there is a farm, the middle row shows 'F' and the farm type. Different types of farms have different basic fertilizer requirements and net incomes from sales. On a farm parcel the bottom row of the parcel shows the code number of the surface water parcel on which the farm parcel's runoff flows.

A farm owner sets a level of fertilizer use for the farm. The higher the fertilizer level, the greater the concentration of nutrients in the runoff from the parcels comprising the farm.

Figure 10.12


TWOCITY
FARM RUNOFF MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
5
6
F 2
7
8
1
2
3
4
9
10 < 35 < 34 < 33 < 32 < 31 < 30 < 29 < 28 < 27 < 26 < 25
F 1 21
F 1 20
F 1 19
24 < 23 < 22 < 21 < 20 < 19 < 18 < 17 < 16 < 15 < 14 < 13 < 12 < 11
F 1
F 3 32

```
PARCELS
-------
   TOP ROW: (FOR SURFACE WATER PARCELS)
            CODE NUMBER OF PARCEL
MIDDLE ROW: FARM TYPE
BOTTOM ROW: PARCEL WHERE RUNOFF FLOWS

....
....  LAKE PARCELS
....
```

```
PARCEL EDGES
------------
>AV<  DIRECTION OF FLOW
----  NO WATER FLOWING
      BETWEEN PARCELS
```

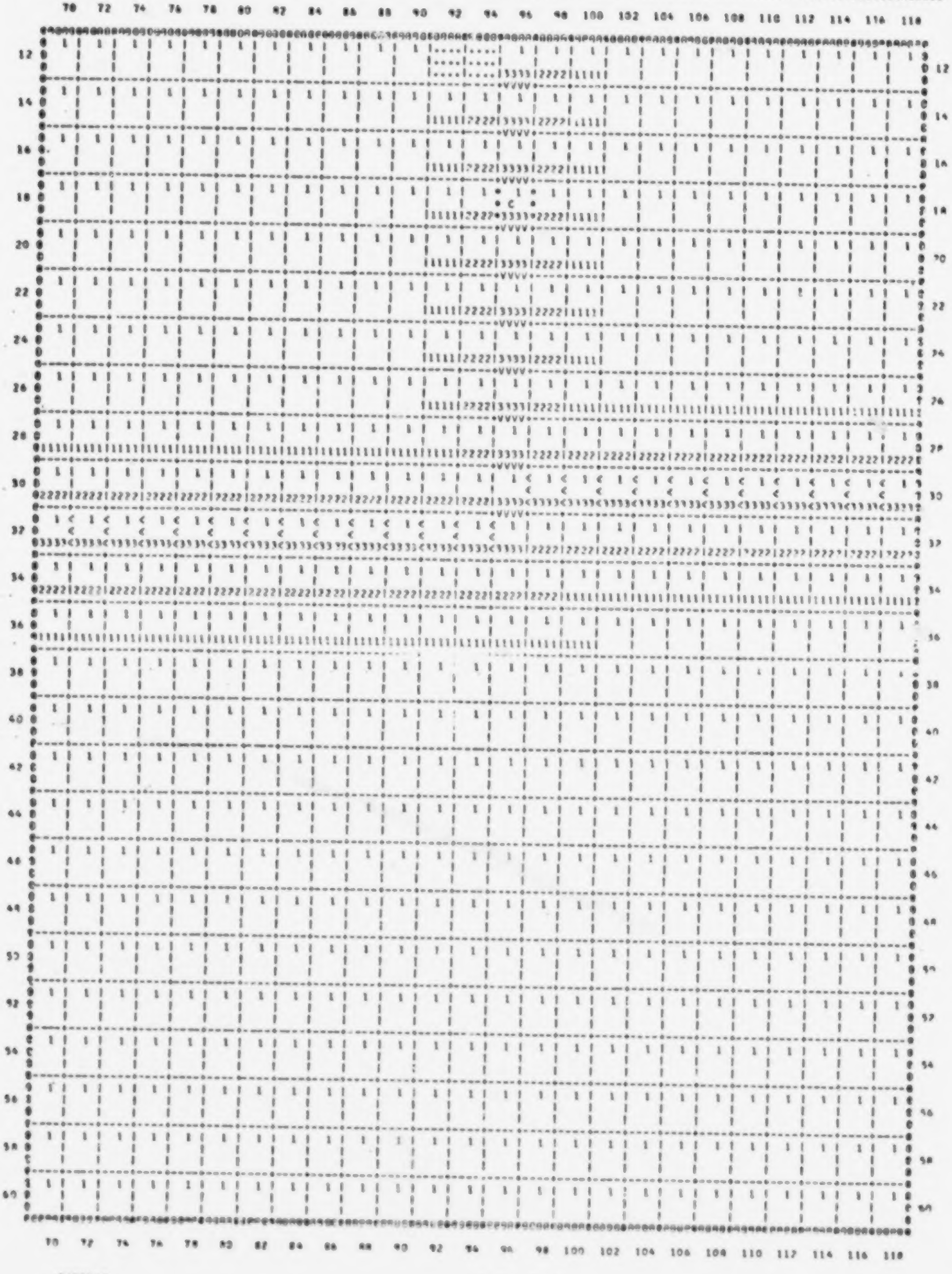
15. River Basin Flood Plain Map

Each parcel has a flood susceptibility between 0 and 3 representing the parcel's likelihood of suffering damage due to its location when a flood occurs in its river basin. A parcel with zero flood susceptibility remains undamaged when there is a flood, and a parcel with a flood susceptibility of 3 suffers the flood's worst damage.

The game director controls the time of occurrence and severity of floods. When a flood occurs, it affects the depreciation of businesses and residences located on parcels with non-zero flood susceptibilities. The degree of damage done to a business or residence by a flood is a function of the severity of the flood as input by the director, the parcel's flood susceptibility, the type of economic activity, and the dam priority of the river basin in which the parcel is located. A river basin's dam priority (A, B, or C) represents the major purpose of the operation of the dams in that river basin. The three sets of priorities involve trade-offs among flood control, pollutant concentrations, and water availability for major recreation areas.

Each of the four factors in degree of damage has an associated numerical value. All four are multiplied together in the calculation of degree of damage.

```
TWOCITY
RIVER BASIN-FLOOD PLAIN MAP                                                            ROUND 2
```


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

```
PARCELS
-------
   TOP ROW: CODE NUMBER OF RIVER BASIN
MIDDLE ROW: (IF DAM) DAM PRIORITY
BOTTOM ROW: FLOOD SUSCEPTIBILITY
....
....  LAKE PARCELS
....

PARCEL EDGES
------------
>AV<  DIRECTION OF FLOW
----  NO WATER FLOWING
      BETWEEN PARCELS
@@@@  DAM ON PARCEL
OOOO  RIVER BASIN BOUNDARY
```

C. Summary Information

1. Demographic and Economic Statistics

The output summarizes a wide variety of information about the simulated region. There are two basic types of information: statistics by jurisdiction and for the region as a whole about local conditions, and measures of interactions between the region and the Outside System. The former provide comparisons between jurisdictions; the latter provide comparisons between the local and Outside systems.

Statistics Regarding Local Conditions

Total population: the number of people (not Pl's), by class.

Percent change over previous year: the total population change, positive or negative, between the current round and the previous round. This is the only local statistic which is given only as a total and not broken down by jurisdiction.

Average population per parcel: the number of people divided by the number of parcels.

Developed land (in parcels): the amount of land area (in parcel equivalents) consumed by public and private developments.

Undeveloped land: the amount of land area (in parcel equivalents) not consumed by developments.

Total land area: the number of parcels.
Assessed value of land in millions: the property tax base.
Assessed value of developments in millions: the development tax base.

Average quality of life index: a measure across classes of the people's average quality of life index. The higher the index, the poorer the quality of life. The indexes may differ significantly within a jurisdiction, but only averages are given here.

Number of registered voters: the number of people eligible to vote, from which the number who actually vote are selected.

Figure - 9.1

```
     TWOCITY
                 DEMOGRAPHIC AND ECONOMIC STATISTICS
*****************************************************************************************************ROUND  1
**********************************************************************************************************

 .-*************************************      TOTAL                  JURISDICTION  JURISDICTION  JURISDICTION
                                           **********                     I             II            III
                                                                     **********    **********    **********
 TOTAL POPULATION                            275500
                  LOW    CLASS                73500                 126000        149500             0
                  MIDDLE CLASS                99000                      0         73500             0
                  HIGH   CLASS               103000                  64000         35000             0
                                                                     62000         41000             0

 PERCENT CHANGE OVER PREVIOUS YEAR                0
 AVERAGE POPULATION PER PARCEL                    0
                                                                         0             0             0
 DEVELOPED LAND (IN PARCELS)                     77
 UNDEVELOPED LAND                               548                     30            46             0
 TOTAL LAND AREA                                625                    266           283             0
                                                                       296           329             0
 ASSESSED VALUE OF LAND
     IN MILLIONS                             12312.                  5321.         6992.            0.

 ASSESSED VALUE OF DEVELOPMENTS
     IN MILLIONS                               421.                   158.          264.            0.
 AVERAGE QUALITY OF LIFE INDEX                   69
 NUMBER OF REGISTERED VOTERS                  88573                     61            75             0
 NO. IN PUBLIC ADULT EDUCATION                    0                  45566         43007             0
                                                                         0             0             0
 AVERAGE EDUCATIONAL LEVEL
       LOW                                       59                     73            47             0
       MIDDLE                                    17                      0            17             0
       HIGH                                      61                     61            62             0
                                            5232824                4061270        278305             0

 NO. OF WORKERS RECEIVING WELFARE             12800                      0         12800             0

 STUDENT/TEACHER RATIO                            7                     13            10             0

 SCHOOL ENROLLMENT
       PUBLIC
       PRIVATE                                48740                  34040         14700             0
                                              20460                      0         20460             0
 HOUSING UNITS
       SINGLE    DWELLINGS                      100
       MULTIPLE  DWELLINGS                       24                     62            38             0
       HIGH RISE APARTMENTS                       6                      7            17             0
                                                                         4             2             0
 VACANCY RATE        (PERCENT)                    4
       NEGATIVE MEANS OVERCROWDED                                       28           -23             0
```

SO-2

Figure - 9.1 (Cont'd)

```
NUMBER OF EMPLOYED WORKERS            79400      35360      44040      0
     LOW                              23000          0      23000      0
     MIDDLE                           31680      20480      11200      0
     HIGH                             24720      14880       9840      0

NUMBER EMPLOYED IN
     LIGHT     INDUSTRY               27160      10240      16920      0
     HEAVY     INDUSTRY               27760      11800      15960      0
     NATIONAL  SERVICES                   0          0          0      0
     CONSTRUCTION INDUSTRY                0          0          0      0
     BUSINESS  GOODS                   2800       1680       1120      0
     BUSINESS  SERVICES                5240          0       5240      0
     PERSONAL  GOODS                   3360       3360          0      0
     PERSONAL  SERVICES                5680       2480       3200      0
     MUNICIPAL SERVICES                1920       1920          0      0
     SCHOOLS                           3880       3880          0      0
     RAIL                                 0          0          0      0
     BUS                                  0          0          0      0
     FEDERAL-STATE                     1600          0       1600      0

NUMBER OF UNEMPLOYED WORKERS           6400          0       6400      0
     LOW                               6400          0       6400      0
     MIDDLE                               0          0          0      0
     HIGH                                 0          0          0      0


UNEMPLOYMENT RATE   (PERCENT)          7.46        0.0      12.69    0.0
     LOW                              21.77        0.0      21.77    0.0
     MIDDLE                            0.0         0.0       0.0     0.0
     HIGH                              0.0         0.0       0.0     0.0

PERCENT EARNING      UNDER $ 5,000       33          5         55      0
PERCENT EARNING $5,000 TO $10,000       37         54         22      0
PERCENT EARNING      OVER $10,000       29         39         21      0
```

Number in public adult education: the number of people who wanted to participate in public adult education programs and were able to do so because programs were provided by their school departments.

Average educational level: by class, the average educational level. This ranges from 0 to 100. The higher a worker's educational level relative to those of other workers, the greater his chances of being hired before the others.

Number of workers receiving welfare: if a jurisdiction does have a program for aid to the unemployed, this number is the number of unemployed workers. The number is zero if there are either no unemployed workers or no welfare program.

Student/teacher ratio: ratio of number of students attending local public schools to number of teachers employed by public schools. This is a factor when students are allocated to public or private schools.

School enrollment: the number of students attending local public schools and the number attending private schools. Students attend private schools only if the public schools in their districts are inadequate.

Housing units: the number of levels of RA (single family), RB (town house, multiple dwellings), and RC (high rise) housing.

Vacancy rate: the ratio of existing housing space to housing space occupied, expressed as a percent. A negative rate means that housing is overcrowded.

Number of employed workers: the number of people holding full-time jobs, by class of worker.

Number employed by type of employer: the number of full-time workers employed by each type of business and government employer.

Number of unemployed workers: by class, the number of workers seeking full-time employment who were unable to obtain jobs.

Unemployment rate (percent): by class, the number of unemployed workers as a percent of the total number of workers who sought full-time jobs.

Earning distribution: the percent of workers earning less than $5,000, between $5,000 and $10,000, and over $10,000 from full-time employment.

2. Transactions With the National Economy

Income from the national economy: federal-state aid received, by type of aid, and income from both basic industry sales of output and bus and rail sales of equipment.

Sales to the national economy: federal-state taxes paid, by type of tax, and purchases of goods, services, and outside-owned land. The only Outside expenditure which can be significantly controlled locally is the purchase of goods and services due to local insufficiency.

National economy business cycle: last round's ratio to "typical income"per unit of output for basic industry, interest rates on loans and bonds from the Outside (expressed as percents), and the average rate of return on outside investments (expressed as percents).

D. Utility Department Output

The Utility Department is responsible for the provision of the utility and water and sewer services which economic activities require in order to operate. The department's utility operations are separate from its water and sewer operations but both are funded from the department's general budget.

Each utility plant has its own district, comprised of full parcels contiguous to the utility plant. A utility district is also a water district, which can contain one water intake treatment plant and one sewage treatment plant. When utility service is installed on a parcel, water and sewer service is also installed.

Utility plants, intake treatment plants, and outflow treatment plants are constructed in levels, each level having a fixed capacity of service. Outflow treatment plants are also constructed as certain types, each type having the ability to remove different amounts of each pollutant type. All of the plants require a fixed amount of land for each constructed level. When a level is demolished, the land becomes available for other Utility Department construction or sale to another owner.

The Utility Department output consists of a financial summary, a report on utility plants, treatment plants, water sampling stations, and miscellaneous other information of concern to the Department.

1. Utility Department Finances

All capital and current revenues and expenditures are summarized on this output. Capital expenditures are made in direct response to player decisions; current expenditures are made in response to policies set by players. All capital revenues and the current revenues of subsidies, bonding, and miscellaneous income are obtained in the manner described in the Introduction to the Government Sector. The Utility Department has two additional sources of current income: income from utility users and income from water users. For the most part, the two types of users are identical. However, some types of basic industries use surface water directly and do not require municipal water although they do require utilities.*

---

* One exception to this rule is the case of an RA with private utilities (well water, septic tanks, etc.). Such an RA does not drain municipally-provided utilities or water.

Figure 8.6

```
******************************************************************************
                           TWOCITY
                                    UTILITY DEPARTMENT FINANCES
******************************************************************************


                    FINANCIAL ACCOUNTING

    CAPITAL                                            CURRENT
 PREVIOUS CASH BALANCE             0.       PREVIOUS CASH BALANCE          6769.

 REVENUES                                   REVENUES
     SUBSIDIES              60000000.         SUBSIDIES                      0.
     BONDING                       0.         BONDING                  7580000.
     MISC. INCOME          270000000.         MISC. INCOME                   0.
                                              UTILITY USERS           11310200.
                                              WATER USERS                    0.


                             -------                                   -------
 TOTAL                     330000000.       TOTAL                     18890200.


 EXPENDITURES                               EXPENDITURES
     UTILITY PLANT CONSTR   30000000.         UTILITY OPERATION       15773330.
     TREATMENT PLANT CONSTR 15599999.         TREATMENT OPERATION      1347152.
     MISCELLANEOUS                 0.         SAMPLING STATIONS         700000.
     EXTENSION OF SERVICE          0.         MISCELLANEOUS                  0.
     LAND PURCHASE            122000.         BOND PAYMENTS            1075191.


                             -------                                   -------
 TOTAL                      45721999.       TOTAL                     18895673.
```

The Department sets the price which any economic activity must pay per utility unit consumed. That price does not vary with the type of economic activity consuming utilities. Each activity does consume a different number of utility units, but the price per unit consumed is the same for every utility user.

The Department also sets the water price per MG consumed, but the price set can vary by the type of economic activity, and, in the case of residences, by class. Utility users always obtain the utility service which they need; the only variable is the price set by the Utility Department. However, the Utility Department might not always be able to provide sufficient water for all of its users' needs, the reasons for which are explained below. A water shortage is relevant to current revenues because water users pay the Department for only the water which they actually obtain from the municipal system.

Capital expenditures are separated into five types: utility plant construction, treatment plant construction, extension of service, land purchase, and miscellaneous. The expenditures under utility plant construction also include utility plant demolition costs. The cost to construct or demolish each level of a utility plant are given on the Master Table. Treatment plant construction costs include the costs to construct and demolish levels of intake treatment plants and the costs to construct and demolish types and levels of effluent treatment plants. The costs for extension of utility service include extension of water and sewer service to those parcels receiving utilities for the first time. Once a parcel has utilities, it never needs more water and sewer service; if a parcel has any utility service of whatever level it has sufficient water and sewer service for any level of any economic activity. The land purchase expenditure category includes income from land sale. Both utility plants and treatment plants require land for construction. Miscellaneous capital expenditures are the total of all cash transfers made from the department's capital account.

There are five types of current expenditures: utility plant operation. treatment plant operation, sampling station operation, bond payments, and miscellaneous. The expenditure for utility plant operation is the total of the operating costs of all of the utility plants in the jurisdiction. Treatment plant operation is the total of the operating costs of all of the intake and outflow treatment plants in the jurisdiction. There is one fixed cost to operate each ambient (river quality) sampling station and another fixed cost to operate each point source (user effluent quality) sampling station. The total operating cost of all sampling stations in the jurisdiction appears as a single current expenditure. Payments on both current and capital bonds are made through the current account. Miscellaneous current expenditures are the total of all cash transfers made from the department's current account.

The new cash balances in both accounts remain in those accounts and are available for expenditure in the following round.

[illegible]. Water Department Reports

Four types of detailed information are shown on this output: intake treatment plant status, outflow (effluent) treatment plant status, municipal sampling station reports, and the water prices which have been set by the department.

The intake treatment plant table has one row per intake plant. Each intake treatment plant has a code number which is identical to the code number of the utility district in which it is located and which it serves. Both the plant code number and its coordinates are given here. An intake plant also has a level, which denotes its maximum capacity (in MGD) to treat water.

The water which is treated at an intake treatment plant may actually be obtained from surface water anywhere in the simulated region, although the water intake for a single utility district must all be from a single parcel having surface water. The coordinates of the parcel on which a district's intake point is located are in the fourth column. The fifth column shows the intake water quality. Intake water quality affects the cost which the department must pay in order to treat the water to drinking water quality. The worse the water, the greater the cost per MG to treat the water.

The total water requirement (in MGD) of all of the water users in the utility district is in the sixth column. The seventh column contains the total amount of water (in MGD) which the department was able to obtain from the surface water at its intake point. The amount obtained is never greater than the amount needed. There are three possible reasons that the amount obtained could be less than the amount needed: 1) the water quality on the parcel on which the intake point is located is 9: 2) the total amount attempted removed by surface water users (municipal intake points or surface water using basic industries) from the parcel on which the intake point is located is greater than the amount of water on the parcel; 3) the intake

Figure 8.2

```
*******************************************************************************************************
                    TWOCITY
              WATER DEPARTMENT REPORTS                                                 JURISDICTION 1
*******************************************************************************************************

INTAKE TREATMENT PLANTS
-----------------------
                                  INTAKE   WATER     WATER                 TOTAL
                          INFLOW  WATER    NEEDED   OBTAINED  CAPACITY   TREATMENT   TREATMENT      INCOME
  PLANT  LOCATION  LEVEL  POINT   QUALITY  (MGD)     (MGD)     (MGD)       COST      COST/MGD     FROM USERS
  -----  --------  -----  ------  -------  ------   --------  --------  ---------   ---------   ----------

    I      9424      4     9624      1     14.45     14.45       26     $   25889   $  1791     $   2010014


OUTFLOW TREATMENT PLANTS
------------------------
                   TYPE              AMOUNT OF    PLANT       TOTAL
                    AND    OUTFLOW   EFFLUENT    CAPACITY   TREATMENT   TREATMENT
  PLANT  LOCATION  LEVEL    POINT     (MGD)       (MGD)       COST      COST/MGD
  -----  --------  -----  -------   ---------   --------   ---------   ---------

    I      9428     TT4     9616      14.45        26      $ 1321263   $ 91436


MUNICIPAL SAMPLING STATION REPORTS
----------------------------------
                                                      BACTERIALS   TEMPERATURE    OIL AND    HIGH      AMOUNT OF
                      BOD       CHLORIDES  NUTRIENTS    (PARTS      DEVIATION    FLOATING   LEVEL       WATER
 DIST  LOCATION    (LBS/MG)     (LBS/MG)   (LBS/MG)    PER MG)     (DEGREES)     SOLIDS    WASTES      (MGD)
 ----  --------    --------     --------   --------   ---------   -----------   --------   ------    ---------

   I     9616        11.65        4.49       26.98       0.0           0.0         NO        NO         14.45

WATER PRICES
------------
               ACTIVITY      PRICE/MG
               --------      --------                                   LA        $       200
                                                                        LB        $       450
                 OUT      $      700         SG        $      450       LC        $       450
                 NS       $      450         MF        $      450       MA        $       450
                 CI       $      450         NL        $      450       MB        $       450
                 BG       $      350         EL        $      450       MC        $       450
                 BS       $      450         TE        $      450       HA        $       300
                 PG       $      450                                    HB        $       450
                 PS       $      450                                    HC        $       450
```

treatment plant has the capacity to process a volume less than the total amount needed by the district's water users. In the first case, no water users supplied by the municipal system receive municipal water; all purchase from the Outside In the second and third cases each water user receives a share of municipally-supplied water proportional to its needs. If both the second and third cases obtain, the lesser amount is removed from the surface water and treated.

The seventh item, total treatment cost, is the plant's operating cost for the year, based on the total water users' annual requirements (in MG), the proportion of their daily needs (MGD) which the district obtained, and the quality of the intake water. The proportion is multiplied by the total annual requirement and then multiplied by the cost per MG to treat water at the intake quality. For example, suppose that a district contained only a BG1 and a TE1, had a level 1 intake plant, quality 4 intake water, and no shortage of water at the intake point. Suppose that the Master Tables showed that: a BG1 requires .17 MGD and 41 MG annually; a TE1 requires 8 MGD and 2080 MG annually; a level 1 intake plant can treat 3 MGD; and the cost per MG to treat quality 4 water is $100. Then the total amount needed (MGD) would be 8.17. The amount obtained would be 3.00, and the capacity would be 3.00. The total treatment cost would be:

3.00/8.17 x (41 + 2080) x $100 = $77882

The treatment cost per MGD is the total treatment cost divided by the MGD obtained.

The last item on the table, income from users, is the total income from the district's sale of water. It is shown on the intake treatment plant table because water users pay the department only for those portions of their water needs which are provided locally. They pay the local price per MG for the number of MG's obtained from the district.

Whereas a water user may obtain some of its water from Outside, all of its effluent is dumped into the municipal sewer system (for municipal water users only). Thus a district receives revenue only for water provided but receives the total amount of effluent generated in the district. On the outflow treatment plant table, each outflow plant has a row. The first two columns contain the code number of the utility district in which the plant is located and which it serves, and the coordinates of the outflow plant.

The third column is the treatment type and level. Level denotes the maximum amount of effluent which the plant can treat. Type denotes the amount of each pollutant removed from the effluent which the plant treats. The four types of plants, in increasing order of pollution removal, are: chlorination (CL), primary treatment (PT), secondary treatment (ST), and tertiary treatment (TT).

The sewage generated by a district may be dumped into surface water anywhere in the simulated region, although all of the outflow for a single district must be on a single surface water parcel. The coordinates of the parcel on which the district's outflow point is located are given in the fourth column. All of the district's effluent, treated or not, is dumped on that parcel.

The fifth column contains the amount of effluent (in MGD) generated by all of the water users in the district. That amount is equal to the amount of water needed shown on the intake treatment plant table. The plant capacity (in MGD) is in the next column and is the maximum amount which can be treated. If the amount of effluent is greater than the plant capacity, the difference between the amount of effluent and the amount treated is dumped untreated at the outflow point. The amount treated has an amount of pollution removed according to the treatment type.

The total treatment cost, the treatment plant's operating cost for the year, is based on the total water users' annual requirements (in MG), the proportion of their effluent which the plant treated, and the treatment cost per MG for the treatment type and level. The proportion is multiplied by the total annual requirement and then by the treatment cost per MG for the treatment type. For example, suppose that the same district in the example above had ST2 effluent treatment, and that the Master Tables showed that a level 2 has a capacity of 8 MGD and that the treatment cost per MG at ST2 is $190. The total treatment cost would be:

$$8.00/8.17 \times (41 + 2080) \times \$190 = \$394,605$$

The last column, treatment cost per MGD, is the total treatment cost divided by the amount treated (in MGD).

The department can set up sampling stations to monitor the concentration of each pollutant in the municipal effluent which it dumps into the surface water. Municipal sampling stations must be located on parcels where municipal systems have outflow points. The municipal sampling station report is a table with one row per sampling station. The first two columns contain the code number of the utility district which the outflow point serves and the coordinates of the outflow point. The next seven columns show the concentration of each pollutant in the effluent being dumped (after any treatment). Oil and floating solids and high level wastes are either present or not; they are not measured in concentrations. Suppose that in the example given above, the Master Table showed the effluent content of a BG1 and a TE 1 to be:

	BOD (LBS/MG)	Chlorides (LBS/MG)	Nutrients (LBS/MG)	Coliform (parts/MG)	Temperature Deviation	Oil & Floating Solids	High Level Wastes
BG1	200	0	0	10	0	No	No
TE1	500	180	100	30	0	No	No

Then the volume of pollution before treatment would be:

BOD: 200 x .13 + 500 x 8 = 4026 Lbs.
Chlorides: 0 x .13 + 180 x 8 = 1440 Lbs.
Nutrients: 0 x .13 + 100 x 8 = 800 Lbs.
Coliform: 10 x .13 + 30 x 8 = 241.3

The amount of pollution to be treated would be 8.00/8.17 of the amount in the effluent. Thus, the amount treated and untreated would be:

	Treated	Untreated
BOD	3945	81
Chlorides	1411	29
Nutrients	784	16
Coliform	236	5

Suppose that the Master Table showed that ST removed:

BOD	Chlorides	Nutrients	Coliform	Temperature	Oil & Floating Solids	High Level Wastes
80%	60%	50%	99%	0%	100%	0%

Then the amount of pollution remaining in the treated effluent would be:

BOD: (100 - 80) x 3945 = 789
Chlorides: (100 - 60) x 1411 = 564
Nutrients: (100 - 50) x 784 = 392
Coliform: (100 - 99) x 236 = 2

The total amount of pollution dumped would be:

BOD; 789 + 81 = 870
Chlorides: 564 + 29 = 593
Nutrients: 392 + 16 = 408
Coliform: 2 + 5 = 7

The sampling station report would show those concentrations to be:

BOD: 106.49 LBS/MG (870/8.17)
Chlorides: 72.58 LBS/MG (593/8.17)
Nutrients: 49.94 LBS/MG (408/8.17)
Coliform: .86 PARTS/MG (7/8.17)

The last column in the table is the total volume of effluent dumped at the outflow point. Actually, the volume of effluent dumped is unimportant, since the amount of surface water on a parcel is constant. What does matter is the total amount of pollution dumped, not its concentration. Once in the surface water, the concentration of each pollutant depends on the volume of the surface water and the amount of each pollutant already in the surface water, not on the amount of effluent.

Water prices are the last section of the Water Department Report. The two-letter code of each activity and the price per MG are listed. The first activity, OUT, is the Outside price per MG which water users pay for any water which they cannot obtain locally. That price is the same for all jurisdictions and is not controlled by the department.

All of the other prices in the list are set by the department. Note that the department does not set prices for basic industries which use surface water, since those industries obtain and treat their own water. The department sets one price for each type of economic activity except residences. Residence prices are set by residence type and by class. The first letter of the two-letter code is the class and the second is the residence type. 'LB' would be low-income living in residence type RB. Water consumption by a P1 varies by class and residence type. In general, high-income consume more water than low-income, and RA residents consume more water than RC residents. See the Master Tables for the exact amounts of water consumption.

3. Sampling Station Report: Point Source Quality

The department can sample the effluent discharged by any economic activities in the jurisdiction at a fixed cost per sampling station. The concentration of a basic industry's pollution is shown after any treatment provided by the industry.

The report is a table consisting of one row per sampling station. The first column shows the coordinates of the activity whose effluent is being sampled. Next are the economic owner and the type and operating level of the activity. The fourth column shows the effluent treatment type and level provided by the activity, but is relevant for basic industries only. A level one treatment plant has the capacity to process all of the effluent normally generated by one level of industry.

The volume of effluent (in MGD) is next. Basic industries which use surface water can recycle some of their water and cut the amount of effluent generated by up to half of the normal amount. Although the amount of effluent can be cut, the amount of pollution generated remains the same. Thus, the pollution concentration is higher in effluent when water is recycled, but no more pollution is present than there would be if there were no recycling.

The remainder of the table shows the concentration of each pollutant in the activity's effluent.

4. Sampling Station Report: Ambient Quality

An ambient sampling station measures the concentration of each pollutant in the surface water as it leaves a parcel and moves to the next parcel. Ambient sampling stations can be set up on any surface water parcels in the jurisdiction at a fixed cost per parcel. The type of information provided on the ambient sampling station report is basically the same as on other sampling station reports, except that the amount of water is the amount in the surface water, and the water is rated in a quality category (1-9).

5. Utility Department Report

This report contains detail on each utility plant in the jurisdiction and detail of importance to the department as a whole (water and utilities) on undeveloped land and outstanding bonds. The detail on utility plants consists of a table on which each row is a utility plant. The first two columns contain the utility district code number and the coordinates of the parcel on which the utility plant is

Figure 8.3

```
****************************************************************************************************************************
                               TWOCITY
                    SAMPLING STATION REPORT: POINT SOURCE QUALITY                                JURISDICTION 1     ROUND  2
****************************************************************************************************************************

                    BUSINESS  TREATMENT                                                BACTERIALS  TEMPERATURE  OIL AND   HIGH
LOCATION  OWNER     TYPE AND  TYPE AND   VOLUME     BOD      CHLORIDES   NUTRIENTS     (PARTS     DEVIATION   FLOATING  LEVEL
                    LEVEL     LEVEL      (MGD)    (LBS/MG)   (LBS/MG)    (LBS/MG)      PER MG)    (DEGREES)   SOLIDS    WASTES
--------  -----     --------  ---------  ------   --------   ---------   ---------   ----------  -----------  --------  ------

   9422     B        RA 1         0       0.10    1070.00      37.00       77.00        5.00        0.0        YES       NO
   9424     C        RA 1         0       0.10    1070.00      37.00       77.00        5.00        0.0        YES       NO
   8826     B        RA 3         0       0.35    1100.00      40.00       80.00        5.00        0.0        YES       NO
   9026     F        RA 3         0       0.35    1100.00      40.00       80.00        5.00        0.0        YES       NO
   9226     E        RA 3         0       0.35    1100.00      40.00       80.00        5.00        0.0        YES       NO
   9426     E        RA 2         0       0.21    1100.00      40.00       80.00        5.00        0.0        YES       NO
   8628     C        RA 3         0       0.24    1250.00      50.00      100.00        5.00        0.0        YES       NO
   8828     B        RA 4         0       0.49    1100.00      40.00       80.00        5.00        0.0        YES       NO
   9228     B        PS 1         0       0.18     100.00      40.00       80.00        5.00        0.0        YES       NO
   9428     A        MF 0         0       0.0        0.0        0.0         0.0        15.00        0.0        NO        NO
   8430     E        RA 4         0       0.39    1223.08       0.0         0.0         0.0         0.0        NO        NO
   8630     E        RA 6         0       0.56    1250.00      48.21       96.41        5.00        0.0        YES       NO
   8830     B        RC 1         0       1.29    1190.70      50.00      100.00        5.00        0.0        YES       NO
   9030     D        RC 2         0       2.61    1179.31      46.05       92.09        5.00        0.0        YES       NO
   9230     E        PG 1         0       0.23     250.00      45.29       90.57        5.00        0.0        YES       NO
   8432     F        RA 6         0       0.48    1250.00       0.0         0.0        20.00        0.0        NO        NO
   8632     D        RA 6         0       0.56    1250.00      50.00      100.00        5.00        0.0        YES       NO
   8832     F        RA 2         0       0.15    1180.00      50.00      100.00        5.00        0.0        YES       NO
   9032     F        RB 3         0       1.38    1206.52      45.33       90.67        5.00        0.0        YES       NO
   9232     F        RC 1         0       0.96    1212.50      47.10       94.20        5.00        0.0        YES       NO
   8634     F        RA 4         0       0.39    1223.08      47.50       95.00        5.00        0.0        YES       NO
   8834     B        RA 3         0       0.24    1250.00      48.21       96.41        5.00        0.0        YES       NO
   9034     E        RB 1         0       0.50    1205.00      50.00      100.00        5.00        0.0        YES       NO
   9234     B        RB 3         0       1.52    1210.53      47.00       94.00        5.00        0.0        YES       NO
   8836     F        RA 5         0       0.48    1250.00      47.37       94.74        5.00        0.0        YES       NO
   9036     C        RA 2         0       0.16    1250.00      50.00      100.00        5.00        0.0        YES       NO
   9038     F        RA 1         0       0.08    1250.00      50.00      100.00        5.00        0.0        YES       NO
```

Figure 8.4

```
              SAMPLING STATION REPORT: AMBIENT QUALITY                             JURISDICTION Z        ROUND  1
*****************************************************************************************************************

                                                  BACTERIALS   TEMPERATURE   OIL AND    HIGH      AMOUNT OF    WATER
               BOD      CHLORIDES    NUTRIENTS     (PARTS       DEVIATION    FLOATING   LEVEL       WATER     QUALITY
 LOCATION   (LBS/MG)    (LBS/MG)     (LBS/MG)      PER MG)      (DEGREES)     SOLIDS    WASTES      (MGD)     RATING
 --------   --------    ---------    ---------    ----------   -----------   --------   ------    ---------   -------

     9620       0.0         0.0         10.20         0.0           0.0          NO        NO       260.00        1
     9622       0.0         0.0          9.22         0.0           0.0          NO        NO       254.00        1
     9624       0.0         0.0          7.86         0.0           0.0          NO        NO       280.00        1
     9626     106.90       53.45       861.54         0.05          0.43         NO       YES       290.00        1
     9612       0.0         0.0          0.0          0.0           0.0          NO        NO       100.00        1
     9614       0.0         0.0          6.67         0.0           0.0          NO        NO       150.00        1
     9616       0.0         0.0          9.70         0.0           0.0          NO        NO       200.00        1
     9618       0.0         0.0         11.29         0.0           0.0          NO        NO       250.00        1
     9628     131.41       50.92       799.11         0.43          0.0         YES       YES       300.00        8
     9630     424.74      135.72      1150.11         1.08         10.66        YES       YES       500.00        8
     9632     401.90      127.26      1125.40         0.98          7.45        YES       YES       510.00        9
     9432     967.50      153.13      1982.20        29.53          5.15        YES       YES       520.00        9
    11830       0.0         0.0          0.0          0.0           0.0          NO        NO        70.00        1
    11630       0.0         0.0          0.0          0.0           0.0          NO        NO        80.00        1
    11430       0.0         0.0          0.0          0.0           0.0          NO        NO        90.00        1
    11230       0.0         0.0          0.0          0.0           0.0          NO        NO       100.00        1
    11030       0.0         0.0          0.0          0.0           0.0          NO        NO       100.00        1
    10830       0.0         0.0          0.0          0.0           0.0          NO        NO       100.00        1
    10630       0.0         0.0          0.0          0.0           0.0          NO        NO       100.00        1
    10430       0.0         0.0         11.25         0.0           0.0          NO        NO       120.00        1
    10230       0.0         0.0          8.45         0.0           0.0          NO        NO       150.00        1
    10030       0.0         0.0          7.01         0.0           0.0          NO        NO       170.00        1
     9830       0.0         0.0          5.60         0.0           0.0          NO        NO       192.00        1
```

Figure 8.5

```
                                 TWOCITY
**********************************************UTILITY DEPARTMENT REPORT*****************************JURISDICTION 1**********
PLANT   LOCATION    LEVEL     UNITS       UNITS      OPERATING      OPERATING
                            INSTALLED    SERVED         COSTS        COST/UNIT        INCOME
------------------------------------------------------------------------------------------------------

  1       94-24       2        5000        1166      15773330.        13527.        11310200.

CHARGE TO CUSTOMERS --       9700 PER UNIT    TOTALS      15773330.                    11310200.

UNDEVELOPED LAND
----------------
        LOCATION  AMOUNT   LOCATION  AMOUNT   LOCATION  AMOUNT   LOCATION  AMOUNT   LOCATION  AMOUNT
        --------  ------   --------  ------   --------  ------   --------  ------   --------  ------
         94-24       7       82-30      4       94-28      9

                           OUTSTANDING BONDS
                           -----------------

   TYPE           ORIGINAL     REMAINING     INTEREST       ANNUAL
                  PRINCIPAL      TERM          RATE         PAYMENT
   ----           ---------    ---------     --------       -------
  CAPITAL          7182128.       8             4.1          464614.
  CURRENT           200000.       1             3.2          104925.
  CURRENT           150000.       2             3.2           78618.
  CURRENT          7430000.       2             3.7         3922430.
```

located. Next is the level of utility plant. Each level has a fixed capacity in terms of the number of utility units which it can provide.

The next two columns show the number of utility units installed on parcels served by the plant. The number of units installed on a parcel is the maximum number which an activity located there can draw upon. The program rejects any construction which would require more utility units than are installed on the parcel. The number of units installed and attached to a plant are always greater than or equal to the number of units served by the plant. The units served are those actually being consumed. Units installed indicates actual and potential consumption. However, a level of a plant has a maximum capacity in terms of units served. That maximum cannot be exceeded.

There is an optimum number of units which a level of utility plant can serve. Below and above that number the operating cost per unit served (equal to a unit of income) is greater than that optimal minimum cost per unit served. Column six, total operating cost for the year, is less informative than column seven, the operating cost per unit served. The last column shows the total income which the district receives for providing utility service. An economic activity pays for only the number of utility units which it drains, regardless of the number installed on the parcel on which the activity is located.

The undeveloped land table shows the location and percent of parcel owned wherever the department owns undeveloped land. Utility plants, intake treatment plants, and outflow treatment plants require land. When a building is constructed, land is subtracted from the department's undeveloped land account.

Each outstanding bond is listed on the bond table, one row per bond. The first item is the type of bond, capital or current. A capital bond has a term of 25 years; a current bond has a term of 2 years. The original principal, remaining term, interest rate, and annual payment are given. The remaining term is the number of rounds after the current round in which the department must make the annual payment. The annual payment is calculated by the computer to pay off the bond in equal installments each year, and the payment is made automatically by the computer from the department's current account.

E. WATER SYSTEM OUTPUT

Water User Effluent Content

Economic activities, municipal sewer systems, and farms dump effluent into the surface water. All businesses except surface water users dump their effluent into municipal systems, which then can treat some or all of the effluent to varying degrees. This section of the output shows in detail the pollution generated by each farm and economic activity. If a basic industry has a treatment plant, the amount of pollution printed is the pollution remaining in the effluent after treatment. Industries can recycle some water (up to 100%), which decreases the amount of water in the effluent but not the amount of pollution in the effluent.

The amount of each pollutant is expressed on this output as 100 times its actual value. The pollution here is not measured in its concentration per MGD, as it is measured at sampling stations. The pollution is a total volume of pollutant in the effluent. The amount of effluent is also expressed as 100 times its actual value.

Oil and floating solids and high level wastes are represented somewhat differently from the other pollutants. They are either present in the effluent or not; they are not measured in volume or concentration. A zero indicates that the pollutant is absent and a one indicates that the pollutant is present.

For a farm parcel, two rows are printed. The first shows the location of the farm parcel and its type. The second shows the location of the parcel on which the farm parcel's runoff flows, the type of farm dumping on that parcel, and the volume of pollutants and water being dumped there from the farm parcel.

River Quality During Surface Water Process

This output shows the amount of pollution present on a parcel during all stages of the surface water process. A surface water parcel is part of a river. The beginning of a river is defined as a parcel having surface water and on which either no other parcel's surface water dumps or two or more parcels' surface waters dump. The last parcel in a river is a parcel that either dumps on no parcel or dumps on a parcel on which two or more parcels dump.

The parcels are listed in the order in which they are processed, i.e., in sequential order of upstream to downstream for each river. The various stages through which

Figure 2.1

```
*****************************************************************************************************************************
                                 TWXCITY
                       WATER USER EFFLUENT CONTENT                                                                  ROUND 2
*****************************************************************************************************************************

            TYPE    TREATMENT                                                                            OIL AND    HIGH     WATER
             AND    TYPE AND    PERCENT       BOD      CHLORIDES   NUTRIENTS   COLIFORM    TEMPERATURE   FLOATING   LEVEL    DUMPED
LOCATION    LEVEL    LEVEL      RECYCLE     (X 100)     (X 100)     (X 100)     (X 100)      (X 100)     SOLIDS     WASTES   (MGDX100)
--------    -----   ---------   -------   ----------   ---------   ---------   ---------   -----------   --------   ------   ------

   9614     F  2
   9614     F  2        0           0            0           0       20000           0             0      0          0        2000
   9814     F  2
   9414     F  2        0           0            0           0       20000           0             0      0          0        2000
   9616     F  2
   9614     F  2        0           0            0           0       20000           0             0      0          0        2000
   9816     F  2
   9615     F  2        0           0            0           0       20000           0             0      0          0        2000
   9619     F  2
   9619     F  2        0           0            0           0       20000           0             0      0          0        2000
   9815     F  2
   9615     F  2        0           0            0           0       20000           0             0      0          0        2000
   9622     RA 1        0           0        10700         370         770          50             0      1          0          17
   9622     RA 1        0           0         6000         180         420          30             0      1          0           6
   9822     RA 2        0           0        12000         360         840          60             0      1          0          12
  10022     RA 4        0           0        27000         810        1890         135             0      1          0          27
   9424     RA 1        0           0        10700         370         770          50             0      1          0          10
   9624     RB 2        0           0        84000        2520        5880         420             0      1          0          84
   9824     RB 3        0           0       132000        3960        9240         660             0      1          0         132
  10024     RB 1        0           0        42000        1260        2940         210             0      1          0          42
  10224     RA 4        0           0        42800        1680        3080         200             0      1          0          40
   8826     RA 3        0           0        38500        1400        2800         175             0      1          0          35
   9026     RA 3        0           0        38500        1400        2800         175             0      1          0          35
   9226     RA 3        0           0        38500        1400        2800         175             0      1          0          35
   9426     RA 2        0           0        23100         840        1680         105             0      1          0          21
  10026     RB 2        0           0        84000        2520        5880         420             0      1          0          84
  10226     RA 3        0           0        21000         630        1470         105             0      1          0          21
  10826     RA 2        0           0        23100         840        1680         105             0      1          0          21
   8628     RA 3        0           0        30000        1200        2400         120             0      1          0          24
   8828     RA 4        0           0        53900        1960        3920         245             0      1          0          49
   9028     RA 1        0           0        10700         370         770          50             0      1          0          17
   9228     PS 1        0           0         1800           0           0         270             0      0          0          18
   9428     TE 1        0          70       400000      144000       80000       24000             0      0          0         420
  10228     RA 4        0           0        27000         810        1890         135             0      1          0          27
  10228     RA 2        0           0        23100         840        1680         105             0      1          0          21
   7630     F  1
   7632     F  1        0           0            0           0       48000           0             0      0          0        1500
   7830     F  1
   7832     F  1        0           0            0           0       48000           0             0      0          0        1500
   9030     F  1
   9032     F  1        0           0            0           0       48000           0             0      0          0        1500
   8430     RA 4        0           0        47700        1880        3760         195             0      1          0          39
   8630     RA 6        0           0        70000        2800        5600         280             0      1          0          56
   9830     RC 1        0           0       153600        5960       11880         645             0      1          0         179
   9030     RC 2        0           0       307800       11820       23640        1305             0      1          0         261
   9230     RG 1        0           0         5750           0           0         460             0      0          0          23
   9650     PA 1     TT 1          40       999072     1265412    29970048           6             0      0          0       26643
   9930     RG 1        0           0         2600           0           0         130             0      0          0          13
  10030     RA 2        0           0        12000         360         840          60             0      1          0          12
  10230     RA 2        0           0        23100         840        1680         105             0      1          0          21
   7632     F  1
   7632     F  1        0           0            0           0       48000           0             0      0          0        1500
   7832     F  1
   7832     F  1        0           0            0           0       48000           0             0      0          0        1500
   8032     F  1
   8032     F  1        0           0            0           0       48000           0             0      0          0        1500
   8432     RA 6        0           0        60000        2400        4800         240             0      1          0          48
   8632     RA 6        0           0        70000        2800        5600         280             0      1          0          56
   9832     RA 2        0           0        17700         690        1360          75             0      1          0          15
   9032     RB 3        0           0       166500        6500       13000         690             0      1          0         139
   9232     RC 1        0           0       116400        4560        9120         480             0      1          0          96
   9432     FO 1     PT 1           0     14700010     1960000    49000000       14702         44100      0          0        4900
   9632     HP 1     ST 1           0      4500016     1912502     5625007        4500        135000      0          0       22500
   9932     RS 1        0           0         2550           0           0         255             0      0          0          17
  10032     RB 2        0           0       115500        4200        8400         525             0      1          0         105
  10232     RA 3        0           0        32100        1110        2310         150             0      1          0          32
   8634     RA 4        0           0        47700        1880        3760         195             0      1          0          39
   8834     RA 3        0           0        30000        1200        2400         120             0      1          0          24
   9034     RB 1        0           0        60250        2350        4700         250             0      1          0          50
   9234     RB 3        0           0       184000        7200       14400         760             0      1          0         152
   9434     RC 1        0           0       144600        5640       11290         600             0      1          0         120
   9834     RC 1        0           0       187200        7380       14760         765             0      1          0         153
  10234     F  3
  10430     F  3        0           0            0           0       45000           0             0      0          0        2500
  10434     F  3
  10430     F  3        0           0            0           0       45000           0             0      0          0        2500
  10534     F  3
  10430     F  3        0           0            0           0       45000           0             0      0          0        2500
   8936     RA 5        0           0        60000        2400        4800         240             0      1          0          48
   9036     RA 2        0           0        20000         800        1600          80             0      1          0          16
   9236     RB 1        0           0        59250        2250        4500         255             0      1          0          51
   9436     RB 2        0           0       123750        4850        9700         510             0      1          0         102
   9636     RB 2        0           0       121750        4650        9300         520             0      1          0         104
   9836     RB 2        0           0       122500        4900        9800         490             0      1          0          98
   9038     RA 1        0           0        10000         400         800          40             0      1          0           8
   9238     RA 1        0           0        10000         400         800          40             0      1          0           8
   9438     RA 3        0           0        30000        1200        2400         120             0      1          0          24
   9638     RA 4        0           0        47700        1880        3760         195             0      1          0          39
   9838     RA 3        0           0        30000        1200        2400         120             0      1          0          24
   9616     UT 1     TT 4           0        16840        6492       38979           0             0      0          0        1445
   9432     UT 2     TT 4           0        19863       20107       59646           0             0      0          0        1941
      0     UT 3        0           0            0           0           0           0             0      0          0           0
      0     UT 4        0           0            0           0           0           0             0      0          0           0
      0     UT 5        0           0         2550           0           0         255             0      0          0          17
```

Figure 2.2

```
**********************************************************************************************************************************
                TWOCITY
            RIVER QUALITY DURING SURFACE WATER PROCESS:   RIVER  2
*******************************************************************************************************************  ROUND  2
**********************************************************************************************************************************
LOCATION  QUALITY         TIME            BOD       CHLORIDES   NUTRIENTS    COLIFORM   TEMPERATURE  AGE OF   AGE OF    AMOUNT
--------  -------  ------------------  (X 100)      (X 100)     (X 100)     (X 100)     (X 100)      OFS      HLW    (MGDX1000)
                                       ---------  ----------  ----------  ----------  -----------  ------   ------   --------


  9630      10     FROM OTHER PARCELS      12118        3297      213962          22            0       0        0      49700

  9630      10     AFTER AGING             12118        3297      213962          22            0       0        0      50000
  9630      10     BEFORE BIO CHANGE        5662        1560       99063          10            0       0        0      23360
  9630      10     AFTER BIO CHANGE         5404        1385       93904           9            0       0        0      21360
  9630      72     EFFLUENT ADDED         999072     1265412    29970048           4            0       0        0      26640
  9630      63     MOVED TO NEXT PARCEL  1004476     1266797    30063952          13            0       0        0      59200

  9632      63     AFTER AGING           1004476     1266797    30063952          13            0       0        0      51900
  9632      63     BEFORE BIO CHANGE      561325      707916    16900432           7            0       0        0      29500
  9632      63     AFTER BIO CHANGE       535810      637124    15782224           6            0       0        0      29500
  9632      92     EFFLUENT ADDED        4500016     1912502     5625007        4500       135000       0        0      22500
  9632      72     MOVED TO NEXT PARCEL  5035826     2549626    21407231        4506       135000       0        0      51900

  9432      72     AFTER AGING           5035826     2549626    21407231        4506       135000       0        0      52000
  9432      72     BEFORE BIO CHANGE     4561296     2309372    19389986        4081       122279       0        0      47100
  9432      72     AFTER BIO CHANGE      4353964     2078434    18214832        3771            0       0        0      47100
  9432      91     EFFLUENT ADDED       14719873     1980107    49059646       14702        44100       0        0       4941
  9432      91     MOVED TO NEXT PARCEL 19073837     4058541    67274478       18473        44100       0        0      52000

  9232      91     AFTER AGING          19073837     4058541    67274478       18473        44100       0        0      53000
  9232      91     BEFORE BIO CHANGE    19073837     4058541    67274478       18473        44100       0        0      53000
  9232      91     AFTER BIO CHANGE     18206832     3652686    63197216       17073            0       0        0      53000
  9232       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  9232      91     MOVED TO NEXT PARCEL 18206832     3652686    63197216       17073            0       0        0      53000

  9032      91     AFTER AGING          18206832     3652686    63197216       17073            0       0        0      54000
  9032      91     BEFORE BIO CHANGE    18206832     3652686    63197216       17073            0       0        0      54000
  9032      91     AFTER BIO CHANGE     17379248     3287417    59367072       15779            0       0        0      54000
  9032       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  9032      91     MOVED TO NEXT PARCEL 17379248     3287417    59367072       15779            0       0        0      54000

  8832      91     AFTER AGING          17379248     3287417    59367072       15779            0       0        0      55000
  8832      91     BEFORE BIO CHANGE    17379248     3287417    59367072       15779            0       0        0      55000
  8832      91     AFTER BIO CHANGE     16589283     2958675    55769056       14583            0       0        0      55000
  8832       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  8832      91     MOVED TO NEXT PARCEL 16589283     2958675    55769056       14583            0       0        0      55000

  8632      81     AFTER AGING          16589283     2958675    55769056       14583            0       0        0      56000
  8632      81     BEFORE BIO CHANGE    16589283     2958675    55769056       14583            0       0        0      56000
  8632      81     AFTER BIO CHANGE     15835224     2662807    52389104       13478            0       0        0      56000
  8632       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  8632      81     MOVED TO NEXT PARCEL 15835224     2662807    52389104       13478            0       0        0      56000

  8432      81     AFTER AGING          15835224     2662807    52389104       13478            0       0        0      57000
  8432      81     BEFORE BIO CHANGE    15835224     2662807    52389104       13478            0       0        0      57000
  8432      81     AFTER BIO CHANGE     15115441     2396526    49214000       12456            0       0        0      57000
  8432       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  8432      81     MOVED TO NEXT PARCEL 15115441     2396526    49214000       12456            0       0        0      57000

  8232      81     AFTER AGING          15115441     2396526    49214000       12456            0       0        0      58000
  8232      81     BEFORE BIO CHANGE    15115441     2396526    49214000       12456            0       0        0      58000
  8232      81     AFTER BIO CHANGE     14428375     2156873    46231328       11512            0       0        0      58000
  8232       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  8232      81     MOVED TO NEXT PARCEL 14428375     2156873    46231328       11512            0       0        0      58000

  8032      81     AFTER AGING          14428375     2156873    46231328       11512            0       0        0      59000
  8032      81     BEFORE BIO CHANGE    14428375     2156873    46231328       11512            0       0        0      59000
  8032      81     AFTER BIO CHANGE     13772539     1941185    43429424       10639            0       0        0      59000
  8032      23     EFFLUENT ADDED              0           0       96000           0            0       0        0       3000
  8032      81     MOVED TO NEXT PARCEL 13772539     1941185    43525424       10639            0       0        0      59000

  7832      81     AFTER AGING          13772539     1941185    43525424       10639            0       0        0      60000
  7832      81     BEFORE BIO CHANGE    13772539     1941185    43525424       10639            0       0        0      60000
  7832      81     AFTER BIO CHANGE     13146514     1747066    40887520        9833            0       0        0      60000
  7832      67     EFFLUENT ADDED             35          36       96037          38           15       6        0       3001
  7832      81     MOVED TO NEXT PARCEL 13146549     1747102    40983557        9871           15       6        0      60000

  7632      81     AFTER AGING          13146549     1747102    40983557        9871           15       0        0      61000
  7632      81     BEFORE BIO CHANGE    13146549     1747102    40983557        9871           15       0        0      61000
  7632      81     AFTER BIO CHANGE     12548978     1572391    38499696        9123            0       0        0      61000
  7632      23     EFFLUENT ADDED              0           0       96000           0            0       0        0       3000
  7632      81     MOVED TO NEXT PARCEL 12548978     1572391    38595696        9123            0       0        0      61000

  7432      81     AFTER AGING          12548978     1572391    38595696        9123            0       0        0      62000
  7432      81     BEFORE BIO CHANGE    12548978     1572391    38595696        9123            0       0        0      62000
  7432      81     AFTER BIO CHANGE     11978569     1415151    36256560        8431            0       0        0      62000
  7432       0     EFFLUENT ADDED              0           0           0           0            0       0        0          0
  7432      81     MOVED TO NEXT PARCEL 11978569     1415151    36256560        8431            0       0        0      62000
```

water is processed are grouped together for a single parcel. The water quality is expressed by a two-digit code, the first digit of which represents the water quality category and the second of which represents the first pollutant type which placed the water quality in that category (1=BOD, 2=Chlorides, etc.). The volumes of the first five pollutant types are expressed as 100 times their actual values.

The values printed for the last two pollutant types, oil and floating solids and high level wastes, are their "ages". Each of these pollutants disappears from the river water after travelling five parcels down the river. Whenever two rivers meet or effluent is dumped into the surface water, the "age" of that pollutant in the surface water becomes the "age" of the youngest source of that pollutant. So, if the surface water had high level wastes age 4 and high level wastes were dumped on the parcel, the new age of that pollutant would be 1.

For each parcel, the pollutant content of the water is given for five different stages. The first, "AFTER AGING", shows no difference in pollutant content from the previous parcel except for the ages of oil and floating solids and high level wastes. Their ages are incremented by one (if the previous age was not zero) until they are greater than 5, in which case they disappear from the river and become age zero. The volume of water is the volume of surface water on the parcel.

"BEFORE BIO CHANGE" is the amount of pollution in the surface water after water has been removed by any intake on the parcel. When water is removed from a parcel, the pollution in that water is also removed. So, if one third of the water on a parcel were removed, one third of the pollution would also be removed. Only oil and floating solids and high level wastes are unaffected when water is removed. The volume of water printed on this line is the volume remaining in the surface water after any water is removed.

After water is removed from the surface water, the remaining pollution undergoes a biodegration process. The third line, "AFTER BIO CHANGE", shows the amount of pollution in the river after that decay process.

Water is dumped on parcels containing municipal outflow points, basic industry surface water users, and agricultural runoff points. The total amount of pollution added to the surface water on a parcel is the fourth line, "EFFLUENT ADDED". That pollution is added together with the pollution remaining in the river after biodegradation, and the result is moved to the next parcel in the river. The total amount of pollution leaving a parcel is shown on the fifth line, "MOVED TO NEXT PARCEL".

For those parcels on which municipal intake points are located, the program prints the utility district code number and amount of water removed by the district on a line between "AFTER AGING" and "BEFORE BIO CHANGE". The amount of water printed is shown as 100 times its actual value.

Water User Costs and Consumption

All water users except farms can incur costs related to water. The types of possible expenditures vary by the type of water user. Prices paid by municipal water users purchasing locally are set by jurisdiction and by type of user.

One cost for use of water can be incurred by any water user: if a water user cannot obtain all of its needed water from its normal source, it automatically purchases the remainder from the Outside at the Outside price per unit of water. Actually the Outside price does not necessarily literally represent a purchase from sources outside of the simulated region; it merely represents a higher cost to a water user to obtain or process its required water. Regardless of how a business obtains its water requirement, it dumps all of its effluent into a municipal system, or if it is a surface water user, into the surface water on its parcel.

A municipal water user obtains all of its needed water from its municipal system unless: 1) the total amount of water attempted removed by surface water users (municipal intake points or surface water using basic industries) from the parcel on which its municipal intake point is located is greater than the amount of water on the parcel; 2) the water quality on the parcel on which its municipal intake point is located is 9; 3) the intake treatment plant of its municipal system has the capacity to process less than the total water requirement of the municipal system's water users. In the second case, no water users supplied by the municipal system receive municipal water; all purchase from the Outside. In the first and third cases each water user receives a share of the municipally-supplied water proportionate to its needs. If both the first and third cases obtain, the lesser amount is removed from the surface water and treated. A business pays the local price set for its business type for that proportion of its annual requirement which is supplied locally and pays the Outside price for that proportion which is not supplied locally.

Figure 2.3

```
***********************************************************************************************************************
                    TWOCITY
            WATER USER COSTS AND CONSUMPTION                                                                 ROUND  2
***********************************************************************************************************************

              TYPE                                  AMOUNT     AMOUNT       ANNUAL          ANNUAL                  INTAKE     OUTFLOW
               AND                      UTILITY    REQUIRED   OBTAINED   CONSUMPTION        WATER     RECYCLING   TREATMENT   TREATMENT
  LOCATION   LEVEL    JURISDICTION     DISTRICT     (MGD)      (MGD)        (MG)            COST        COST        COST        COST
  --------   -----    ------------     --------   --------   --------   -----------     ---------   ---------   ---------   ---------

     9422    RA 1          1               1         0.10       0.10           36          14580           0           0           0
     9622    RA 1          2               2         0.06       0.01           21          14220           0           0           0
     9822    RA 2          2               2         0.12       0.02           43          28440           0           0           0
    10022    RA 4          2               2         0.27       0.04           97          64440           0           0           0
     9424    RA 1          1               1         0.10       0.10           36          14580           0           0           0
     9624    RB 2          2               2         0.84       0.13          302         199980           0           0           0
     9824    RB 3          2               2         1.32       0.20          475         314640           0           0           0
    10024    RB 1          2               2         0.42       0.06          151         100440           0           0           0
    10224    RA 4          2               2         0.40       0.06          144          95400           0           0           0
     8826    RA 3          1               1         0.35       0.35          126          56700           0           0           0
     9026    RA 3          1               1         0.35       0.35          126          56700           0           0           0
     9226    RA 3          1               1         0.35       0.35          126          56700           0           0           0
     9426    RA 2          1               1         0.21       0.21           75          34020           0           0           0
     9626    CR 0          2               2         0.0        0.0             0              0           0           0           0
    10026    RB 2          2               2         0.84       0.13          302         199980           0           0           0
    10226    RA 3          2               2         0.21       0.03           75          50220           0           0           0
    10826    RA 2          2               2         0.21       0.03           75          50220           0           0           0
     8628    RA 3          1               1         0.24       0.24           86          17280           0           0           0
     8828    RA 4          1               1         0.49       0.49          176          79380           0           0           0
     9028    RA 1          1               1         0.10       0.10           36          14580           0           0           0
     9228    PS 1          1               1         0.18       0.18           55          25110           0           0           0
     9428    MF 0          1               1         0.0        0.0             0              0           0           0           0
     9828    TE 1          2               2         5.20       0.78         1352         885560      291200           0           0
    10028    RA 4          2               2         0.27       0.04           97          64440           0           0           0
    10228    RA 2          2               2         0.21       0.03           75          50220           0           0           0
     8430    RA 4          1               1         0.39       0.39          140          34380           0           0           0
     8630    RA 6          1               1         0.56       0.56          201          40320           0           0           0
     8830    RC 1          1               1         1.29       1.29          464         208980           0           0           0
     9030    RC 2          1               1         2.61       2.61          939         422819           0           0           0
     9230    PG 1          1               1         0.23       0.23           71          32085           0           0           0
     9630    PA 1          2               2       266.40     266.40        69264              0     6926400     1385280           0
     9830    BG 1          2               2         0.13       0.02           40          26660           0           0           0
    10030    RA 2          2               2         0.12       0.02           43          28440           0           0           0
    10230    RA 2          2               2         0.21       0.03           75          50220           0           0           0
     8432    RA 6          1               1         0.48       0.48          172          34560           0           0           0
     8632    RA 6          1               1         0.56       0.56          201          40320           0           0           0
     8832    RA 2          1               1         0.15       0.15           54          17100           0           0           0
     9032    RB 3          1               1         1.38       1.38          496         223560           0           0           0
```

A surface water user obtains all of its needed water from the surface water unless: 1) the surface water quality is 9; 2) the total amount of water attempted removed from the parcel by itself and any municipal intake points located on the parcel is greater than the amount of water on the parcel. In the first case the industry buys all of its water from the Outside at the Outside price per unit of water. In the second case, the industry receives from the surface water an amount proportionate to its requirement and buys the remainder from the Outside.

On this output, the number printed under AMOUNT REQUIRED is the water user's daily water requirement. The AMOUNT OBTAINED is the amount of water obtained from the water user's normal source of water. The annual consumption is a function of the activity's type, level, and, in the case of basic industries, amount of recycling. The annual water cost is the total cost which the activity pays for water in that round. A surface water user which obtains all of its water from the surface water has zero cost here.

Only surface water using basic industries can incur recycling, intake treatment, and outflow treatment costs. A business's recycling cost is a function of its amount of recycling and its normal water requirement. Its intake treatment cost has an additional variation for the quality of the intake water before it is processed. Outflow treatment costs vary by the industry's volume of effluent and the type of treatment provided. All three costs are shown on this output as total annual costs.

4. Coliform and Pollution Index Values (Map)

The coliform concentration in the surface water on a parcel affects the health index of that parcel and adjoining parcels. A parcel adjoins a surface water parcel if any of its corners touches a surface water parcel's corner. The coliform count on a parcel which adjoins a surface water parcel is the highest count of all of the surface water parcels which it adjoins. When used in a parcel's health index, the coliform count is divided by 4 and can have a maximum value of 50.

A parcel's pollution index contributes to its environmental index. It is one of two indexes in the model which can be negative; good water quality contributes to the desirability of surface water parcels and bordering parcels. For a parcel containing surface water, the pollution index is:

$$(W-3.5)^3$$

where W is the surface water quality rating.

Figure 2.4

```
*******************************************************************************************************************************
                          TWOCITY
                 COLIFORM AND POLLUTION INDEX VALUES
*******************************************************************************************************************************ROUND  1
    
       70   72   74   76   78   80   82   84   86   88   90   92   94   96   98  100  102  104  106  108  110  112  114  116  118
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  12|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   3|   3|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 12
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  14|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 14
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  16|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   2|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 16
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  18|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 18
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  20|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   2|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 20
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  22|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|  -7| -15|  -7|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 22
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  24|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|  -7| -15|  -3|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 24
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  26|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   1|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 26
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  28|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   8|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 28
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|  22|  24|  26|  29|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  30|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   8|   3|   3|   3|   1|   1|   1|   1|   1|   1|   1|   1|
    |   0|   0|   0|   0|   0|   0|   0|  83|  83|  83|  83|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 30
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|  20|  22|  24|  26|  29|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  32|   9|   9|   9|   9|   9|   9|   9|   9|   9|   9|   9|   9|   9|   9|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0| 166| 166| 166| 166| 166|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 32
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|  24|  26|  29|  29|  29|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  34|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|  83|  83|  83|  83|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 34
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  36|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 36
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  38|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 38
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  40|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 40
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  42|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 42
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  44|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 44
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  46|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 46
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  48|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 48
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  50|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 55
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  52|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 52
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  54|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 54
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  56|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 56
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  58|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 58
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
  60|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|
    |   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0|   0| 60
    +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
       70   72   74   76   78   80   82   84   86   88   90   92   94   96   98  100  102  104  106  108  110  112  114  116  118

                     PARCEL KEY:
                TOP ROW: COLIFORM COUNT
             MIDDLE ROW: WATER QUALITY RATING
             BOTTOM ROW: POLLUTION INDEX
```

The pollution index of a parcel bordering a surface water parcel on a full side is half of the average pollution indexes of the surface water parcels which it borders.

Pollution indexes are calculated for lake parcels and parcels bordering lake parcels. Since the concentration of individual pollutants is never specified for lake parcels, there are no coliform counts for them.

V. Types of Decisions Available to the Utility Department

A. Summary of Decisions

The decisions which the Utility Department can make fall into two categories: those which are jurisdiction-wide in scope and those that pertain to individual parcels and districts.

Jurisdiction-wide
- Change Utility Prices
- Change Water Prices
- Transfer Cash

Individual Parcels or Districts
- Buy or Sell
- Install or Change Utility Service
- Construct or Demolish a Utility Plant
- Construct A Water Intake Treatment Plant
- Construct A Sewage (Outflow) Treatment Plant
- Change A Water Intake Point
- Change A Water Outflow Point
- Create or Remove a Water Sampling Station

The department may make as many of each of those decisions as it wishes. It may choose to make no decisions, in which case price policies and facilities operate as they did in the previous year. No new development or cash transfer is undertaken.

B. Input Format

Local system decision-makers (such as the Utility Department) use a standardized input form (Figure UT-3.2) when making decisions that must be processed by the computer.

The standard message format is:

$CODE/ = dm/a, b, c, d, ...

1. $CODE stands for the type of decision code. The UT Department has the option to make decisions that use the following decision codes.

$OTHER (utility prices)
$CVPT (utility service)
$CASH (transfer cash)
$PU (land transfer)
$OUBLD (construct or demolish)
$WRBLD (treatment plants, intake and outflow points, sampling stations)
$WRPRC (water prices)

2. "=dm" is the decision-maker, which for the utility Department is UT1, UT2, or UT3, depending upon the appropriate jurisdiction number. A jurisdiction number must always follow the UT decision-maker code, even if there is only one active jurisdiction.

3. The columns "a", "b", and so forth are filled in with the appropriate information depending upon the particular decision.

Note that there is a slash (/) after the decision code and after the decision-maker code. There are commas separating all other bits of information. Note also that the decision-maker code is prefaced by an equals sign (=).

INPUT FORM

Note: When filling out this form, refer to input description form in the manual.

Please write clearly; distinguish between 1 (one) and "I" (eye), "Ø" (oh) and "0" (zero); be sure to fill in numbers exactly as required; omitting commas within numbers (100000)

RIVER
BASIN
MODEL

Decision Code | Decision-Maker | a | b | c | d | e | f | g | h | i | j | k

$_____ / =_____ / _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
$_____ / =_____ / _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
$_____ / =_____ / _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____
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$_____ / =_____ / _____, _____, _____, _____, _____, _____, _____, _____, _____, _____, _____

UTILITY DEPARTMENT: INPUT EXPLANATION FORM

Type of Decision	Code	Decision-Maker	a	b	c	d	e	f	g
Purchase or bid on land	$PU	UT1, UT2, or UT3	location	price (in $1000's)	seller (economic decision-maker or department or OU)	percent of parcel (0 if all)			
Change utility service	$CVPT	UT1, UT2, or UT3	US	location	location of plant serving	new level of service			
Set Utility prices	$OTHER	UT1, UT2, or UT3	P	new price per unit of utility service					
Construct, upgrade or demolish a utility plant	$OUBLD	UT1, UT2, or UT3	site location	UT	old level (0 if new plant)	new level			
Transfer cash	$CASH	UT1, UT2, or UT3	C	receiver (economic or social decision-maker or department and jurisdiction)	amount (in dollars)	from CAPital or CURrent account	if economic decision-maker receiving, PVT; if social receiving, class receiving (H,M, or L); if department receiving, to CAPital or CURrent account	0	if social receiving, location receiving

Type of Decision	Code	Decision Maker	a	b	c	d	e	f	g
Set Water Prices	$WRPRC	UT1, UT2, or UT3	two-letter activity Code (AL for all water users)	price per MG					
Build or Demolish Intake Treatment Plants	$WRBLD	UT1, UT2, or UT3	T	location	IN	old level	new level	location of utility plant serving district	
Build or Demolish Outflow Treatment Plants	$WRBLD	UT1, UT2, or UT3	T	location	OUT	old level	new level	location of utility plant serving district	two-letter code of treatment type
Locate Intake and Outflow Points	$WRBLD	UT1, UT2, or UT3	P	location	IN if intake, OUT if outflow	0	0	location of utility plant serving district	
Locate Water Sampling Stations	$WRBLD	UT1, UT2, or UT3	S	location (if sample of municipal outflow, give location of utility plant in district which outflow point serves)	A, if ambient, P if Industrial effluent, M if municipal outflow point	0 if new; 1 if old and being removed	1 if new; 0 if old and being removed		

C. Sample Decisions for the Utility Department

Jurisdiction-wide Decisions

A.1 Change Utility Prices - The Utility Department in Jurisdiction 1 sets the price for a unit of utility at $11,000.

A.2 Change Water Prices - The Utility Department in Jurisdiction 1 set all the water prices to $450 per MG. The Utility Department used selective pricing and set the price for TE at $400/MG, for MF at $350/MG, and for HA at $475/MG. The price of water to all the other municipal users remained at the previous level.

A.3 Transfer Cash - The Utility Department in Jurisdiction 3 transferred $250,000 from its capital account to its current account.

Parcel or District Specific

B.1 Purchase Land - The Utility Department in Jurisdiction 2 purchased 10 percent of the land on parcel 9642 from Team A for $650,000. This land may be used to construct a utility plant and/or a water treatment plant.

B.2 Change Utility Service - The Utility Department in Jurisdiction 1 decides to provide level 5 utility service to parcel 9850 from its utility plant at 10054. Parcel 9850 must be contiguous to a parcel that is presently receiving utility service from the plant at 10054.

B.3 Construct a Utility Plant - The Utility Department in Jurisdiction 1 decides to construct a level 2 utility plant on the land it owns on parcel 10248.

B.4 Construct Intake and Outflow Plant - The Utility Department decides to build a level 2 intake plant at 10444 and a level 2 outflow plant with tertiary treatment (TT) at 10850 and associate these with the water and utility district serviced by the new utility plant at 10248.

B.5 Locate Intake and Outflow Points - The Utility Department in Jurisdiction 1 decides to place the intake point for the water district served by the utility plant at 10248, at 10644 and the outflow point at 11050.

B.6 Locate Sampling Stations - The Utility Department in Jurisdiction 3 decides to operate an ambient sampling station at 7618 and close down an ambient sampling station at 7820. Furthermore, it decides for measure the outflow - pollution of the water district defined by the utility plant at 7836 and to measure the pollution being dumped by the CR3 on parcel 8038.

SAMPLE DECISION INPUTS FOR THE UTILITY DEPARTMENT

	Decision Code	Decision-Maker	a	b	c	d	e	f	g	h	i	j
A.1	$ ØTHER /	= UT1 /	P	11000								
A.2	$ WRPRC /	= UT1 /	AL	450								
A.2	$ WRPRC /	= UT2 /	TE	400/	MF	350/	HA	475				
A.3	$ CASH /	= UT3 /	C	UT3	250000	CAP	CUR					
B.1	$ PU /	= UT2 /	9642	650	A	10						
B.2	$ CVPT /	= UT1 /	US	9850	10054	5						
B.3	$ ØUBLD /	= UT1 /	10248	UT	0	2						
B.4	$ WRBLD /	= UT1 /	T	10444	IN	0	2	10248				
B.4	$ WRBLD /	= UT1 /	T	10850	OUT	0	2	10248	TT			
B.5	$ WRBLD /	= UT1 /	P	10644	IN	0	0	10248				
B.5	$ WRBLD /	= UT1 /	P	11050	OUT	0	0	10248				
B.6	$ WRBLD /	= UT3 /	S	7618	A	0	1 /	S	7820	A	1	0
B.6	$ WRBLD /	= UT3 /	S	7836	M	0	1					
B.6	$ WRBLD /	= UT3 /	S	8038	P	0	1					

VI. MASTER SHEETS FOR THE UTILITY DEPARTMENT

A. PLANNING MASTER TABLE (LEVEL ONE CHARACTERISTICS)

ACTIVITY	Percent of a Parcel	(Maximum Possible Levels)	Minimum Level of Utility Service	Annual Utility Units Consumed	Construction Costs (Market Value)	Full Time Employees PH	PM	PL	Terminal Units	MS Drain (MS Capacity Units)
FL	28	(3)	1	50	300	8	8	35	1000	150
SG	40	(2)	1	100	240	14	18	23	10000	50
MP	48	(2)	7	700	240	19	18	18	6000	200
MF	20	(5)	1	100	320	24	18	17	2000	150
NL	15	(6)	1	100	150	21	20	18	1000	100
EL	12	(8)	2	200	140	30	18	17	1000	150
TE	12	(8)	2	200	180	25	22	15	2000	200
FO	20	(5)	3	300	230	15	19	24	3000	250
TA	6	(16)	1	100	120	15	10	30	1000	150
PA	16	(6)	3	300	250	23	17	20	3000	200
CR	28	(3)	4	400	250	24	24	14	3000	300
NS	12	(8)	1	76	50	23	9	9	NA	50
BG	12	(8)	2	112	25	14	7	8	One per CU sold	25
BS	10	(10)	1	71	10	20	9	9	NA	10
PG	12	(8)	1	99	30	8	13	23	NA	30
PS	12	(8)	1	77	10	6	11	16	NA	10
RA	2	(50)	1	4	1	NA	NA	NA	NA	10
RB	2	(50)	1	26	6	NA	NA	NA	NA	60
RC	2	(50)	2	117	25	NA	NA	NA	NA	250

B. MASTER SHEET FOR THE UTILITY DEPARTMENT

General Characteristics

Level of Service	Installation Costs (million)	Number of Utility Units Installed
1	2	100
2	4	200
3	5	300
4	6	400
5	8	500
6	11	600
7	14	700
8	18	900
9	35	2,500

Operating Costs for a UTI as a Function of the Number of Utility Units Served

Utility Units Served	Per Unit Operating Costs	Total Operating Costs
300	$20,000	$6,000,000
600	13,333	8,000,000
900	9,630	8,666,667
1200	7,778	9,333,333
*1500	*6,667	*10,000,000
1800	7,407	13,333,333
2100	7,936	16,666,666
2200	8,080	17,777,778

*The least cost design capacity of a UT1.

C. UTILITY DEPARTMENT MASTER TABLE

	Utility (unit)	Water (MG)
Normal Price of Service	$10,000	1/

	Utility Plant	Utility Level	Intake	Outflow
Cost of Lowest Level Plant (millions)	$30	$2	$.1-4.5	$.1-4.5 2/
Capacity	2400	100		3 MGD
Typical Operating Cost Per Capacity Unit	$7000 to $8000		0-$600 3/	$25-300 2/
Land Requirement	6%	None	1%	1%

Intake Treatment Costs per MG

Water Quality Level

	1	2	3	4	5	6	7	8	9
UT	5	60	80	100	180	300	450	600	N.A.

Annual Cost to Operate an Ambient Water Quality Sampling Station ...$50,000

Annual Cost to Operate a Point Source Water Quality Sampling Station.$25,000

1/ Water prices may be set by type of user

2/ Depending upon treatment type

3/ Depending upon water quality

D. CHARACTERISTICS OF OUTFLOW TREATMENT PLANTS

Level of Treatment Plant

	1	2	3	4	5	6	7	8
Maximum Capacity (MGD)	3	8	16	26	40	60	90	200
Land Requirement (% of Parcel)	1	2	3	4	5	6	7	8
Construction Costs (millions of dollars)								
CL	.1	.2	.4	.6	.8	1.0	1.2	1.6
PT	.5	1.0	2	3	4	5	6	8
ST	1.5	3.0	6	9	12	15	18	24
TT	4.5	9.0	18	27	36	45	54	72
Operating Costs (dollars per MG)								
CL	25	24	23	22	21	20	19	18
PT	100	95	90	85	80	75	70	65
ST	200	190	180	170	160	150	140	130
TT	300	285	270	255	240	225	210	195

Intake treatment plants have the same construction costs as ST outflow treatment plants.

Percent Pollution Removed by Treatment Types

	CL	PT	ST	TT
BOD	0	50	80	99
Chlorides	0	0	60	99
Nutrients	0	0	50	70
Coliform	99	99	99	100
Temperature	0	0	0	100
Oil and Floating Solids	0	100	100	100
High Level Wastes	0	0	0	100

E. Pollution Characteristics of Economic Activities

	Water Consumption			Pollution Generated						
				Pounds Per Mg						
Surface Water Users	MGD	Days Per Year	MGY	BOD	CL	NU	Parts Per MG COLI	Temperature	OFS	HLW
FL	61	260	15,860	600	100	1000	20	9	1	0
MP	225	260	58,500	1000	170	500	20	6	1	0
FO	49	260	12,740	6000	400	10000	300	9	1	0
TA	17	260	4,420	6000	130	4000	20	18	1	1
PA	333	260	86,580	3000	380	3000	150	16	1	1
CR	31	260	8,060	2000	500	8000	50	4	1	1
Municipal Water Users										
Industries										
SG	10	260	2,600	500	100	1000	10	0	0	0
MF	9	260	2,340	500	150	700	30	0	1	0
NL	12	260	3,120	400	150	100	20	0	0	0
EL	5	260	1,300	800	200	200	20	0	0	0
TE	8	260	2,080	500	180	100	30	0	0	0
Commercial										
NS	.18	260	47	100	0	0	20	0	0	0
BG	.13	312	41	200	0	0	10	0	0	0
BS	.17	312	53	150	0	0	15	0	0	0
PG	.23	312	72	250	0	0	20	0	0	0
PS	.18	312	56	100	0	0	15	0	0	0
Residential										
HA	.08	364	29	1250	50	100	5	0	1	0
HB	.07	364	25	1250	50	100	5	0	1	0
HC	.06	364	22	1250	50	100	5	0	1	0
MA	.07	364	25	1100	40	80	5	0	1	0

Pollution Characteristics of Economic Activities (Cont'd)

Municipal Water Users	Water Consumption			Pollution Generated						
	MGD	Days Per Year	MGY	Pounds Per Mg BOD	Pounds Per Mg CL	Pounds Per Mg NU	Parts Per MG COLI	Temperature	OFS	HLW
Residential (Cont'd)										
MB	.05	364	18	1100	40	80	5	0	1	0
MC	.03	364	11	1100	40	80	5	0	1	0
LA	.03	364	11	1000	30	70	5	0	1	0
LB	.03	364	11	1000	30	70	5	0	1	0
LC	.02	364	7	1000	30	70	5	0	1	0

F. WATER MASTER TABLE

Physical Characteristics

Location - parcel number
Type - river of lake
Volume flowing to next parcel - MGD
Rate of flow - parcels per day.

Quality of Water

Water Quality Rating	Comment
1	Drinkable - best quality water
2	Drinkable with minor treatment
3	Swimable - direct body contact possible
4	Boating and Fishing - indirect body contact
5	Fair esthetic value
6	Poor esthetic value - treatable at moderate cost
7	No esthetic value - treatable at high cost
8	Negative esthetic value - treatable at very high cost
9	Nonusable water

Types of Pollution

Symbol	Name	Units of Measure
BOD	Biochemical Oxygen Demand	Pounds per million gallons of water
CL	Chlorides	LBS/MG
NO_3	Nutrients	LBS/MG
CO	Coliform Bacteria	Parts per Million gallons
T	Temperature Deviation	Degrees (°)
OFS	Oil and Floating Solids	Yes or No
HLW	High Level Waster	Yes or No

G. Elimination of Three Pollutants Due to Time in the Water

	Percent of Original Pollutant Remaining at the End of a Flow Through a Parcel		
Rate of Flow of the River (parcels per day)	BOD	Nutrients	Coliform
1	50	33	17
2 (sluggish)	75	67	58
4	89	83	79
6 (slow)	92	89	86
8	96	92	90
11 (average)	96	94	93
15	97	96	95
22 (fast)	97	97	96
30	98	98	97
44 (rapid)	99	99	98

H. BIODEGREDATION OF POLLUTANTS

Eleven parcels per day is the typical normal rate of flow of water in the RIVER BASIN MODEL. The following table shows the percent or amount of each pollutant if the water volume does not vary and the rate of flow of the river is eleven parcels per day.

	BOD	NUTRIENTS	COLIFORM	TEMP	O&S HLW
Start	100%	100%	100%	10°	1
Parcels Downstream					
1	96	94	93	10°	1
2	92	88	86	7°	1
3	88	83	80	4°	1
4	84	78	74	1°	1
5	81	73	69	0	1
6	78	69	64	0	0
7	75	65	60	0	0
8	72	61	56	0	0
9	69	57	52	0	0
10	66	54	48	0	0
11	63	52	45	0	0
12	60	49	42	0	0
13	58	46	39	0	0
14	56	43	36	0	0
15	54	40	33	0	0

I. Definition of the Nine Comprehensive Water Quality Levels

Pollutant Types (Maximums)	Water Quality Levels 1	2	3	4	5	6	7	8	9
BOD (LBS/MG)	10	20	30	40	60	100	150	300	> 300
Chlorides (LBS/MG)	5	10	15	20	30	40	60	80	> 80
Nutrients (LBS/MG)	25	50	100	200	400	800	1600	3200	> 3200
Coliform Bacteria (parts per MG)	2	6	12	20	40	70	120	160	> 160
Temperature	0	0	1	2	4	7	10	14	> 14
Oil & Floating Solids	0	0	0	0	0	> 0	> 0	> 0	> 0
High Level Wastes	0	0	0	0	0	0	0	> 0	> 0

Explanation of the Table

In order to determine the water quality level or index of given amounts of water, take the concentrations of each of the seven pollutant categories and calculate the water quality level based upon each pollutant separately. For example, a BOD concentration of 25 LBS/MG would yield an index of 3, coliform bacteria of 169 parts per MG would yield an index of 9, and the presence of oil and floating solids would allow the water quality to be no better than 6. The worst (highest) water quality index that was calculated using the pollutant types separately, is assigned to the given amount of water. If the water on parcel x had the three pollutants described above, it would be assigned water quality index of 9.

Looked at another way, water quality level 4 is attained when a body of water has concentrations of BOD that exceed 30 but fall below 41, coliform bacteria concentrations above 12 but below 21, etc.

VII. Water Quality Officer

Legislative Options:

1. Require a certain minimum level of treatment at all effluent discharge points.
   - Required only of industries
   - Required only of municipal system
   - Required of all

2. Allow an absolute maximum quantity or concentration of pollutants.
   - in quantity of a specific pollutant/MG
   - in total quantity of a specific pollutant (LBS, parts, etc.)

Economic Options:

1. Charge an Effluence Tax
   - Charge tax per quantity of pollutants discharged (by type)
   - Charge tax per concentration of pollutants discharged
   - Charge tax according to the size of operation of the polluting activity
     . according to quantity of effluent
     . according to gross or net income

2. Issue Permits
   - Set price for permit, with each permit allowing a specific quantity of pollutants.
   - Limit number of permits and allow open market bidding.

Enforcement Options:

1. Legislative action
   - Fines in absolute or graduated amounts
   - Shut down of plant
   - Imprisonment of decision-maker

2. Direct fines levied not by legal system but by Water Department

Decision Making Options:

1. Locate and Operate Sampling Stations

2. Select Ambient Standards

3. Choose Regulative Option

4. Enforce Chosen Regulative Option

Sequence of Computer Print-Out

Although sections of the computer output can be distributed in any order and in any combination to players, it is printed in a fixed order with which the director should become familiar. The overall order of output is:

1. Migration
2. Water System
3. Employment
4. Commercial Allocation
5. Social Sector
6. Economic Sector
7. Social and Economic Summaries
8. Government Detail
9. Summary Statistics
10. Maps

Within each of these major output sections there are several subsections. An additional section of print-out results from the processing of decisions on a data base. That print-out, called EDIT, has no fixed sequence within it; the order of decision input is the order in which EDIT processes and lists player and director decisions. The EDIT print-out is separate from the print-outs listed above. These print-outs reflect the simulated region's status in response to the previous year's data base and any changes made to it through EDIT.

Each subsection of output has its own title, but on every subsection the heading for the data base and the round number are printed. A list of the titles of print-out sections in the order in which they are printed and a description of each are given below and are summarized in Figure 4.

Print-Out Section	Description
1. Migration	
Environmental Indexes	For each class which can live on each residence parcel, this shows the value of each component of the environmental index based on last round's pollution index, MS use index and school use index and this round's residence quality, rent, tax rates, and welfare rates.

Figure 4

RIVER BASIN MODEL OUTPUT

1. Migration	1.1	Environmental Indexes
	1.2	Personal Indexes
	1.3	Dissatisfaction Cutoffs
	1.4	Migration Detail
	1.5	Migration Statistics
	1.6	Migration Summary
2. Water System	2.1	Water User Effluent Content
	2.2	River Quality During Surface Water Process
	2.3	Water User Costs and Consumption
	2.4	Coliform and Pollution Index Values
3. Employment	3.1	Employment Selection Information for PL Class
	3.2	Employment Selection Information for PM Class
	3.3	Employment Selection Information for PH Class
	3.4	Part-Time Work Allocation for PH Class
	3.5	Part-Time Work Allocation for PM Class
	3.6	Part-Time Work Allocation for PL Class
	3.7	Employment Summary
4. Commercial Allocation		
	4.1	Personal Goods Allocation Summary
	4.2	Personal Services Allocation Summary
	4.3	Business Goods Allocation Summary
	4.4	Business Services Allocation Summary
	4.5	Government Contracts
	4.6	Terminal Demand and Supply Table
	4.7	Terminal Allocation Map
5. Social Sector	5.1	Dollar Value of Time
	5.2	Social Decision-Maker Output
	5.3	Social Boycotts
6. Economic Sector	6.1	Farm Output
	6.2	Residence Output
	6.3	Basic Industry Output
	6.4	Commercial Output
	6.5	Economic Boycott Status
	6.6	New Construction Table
	6.7	Land Summary
	6.8	Loan Statement
	6.9	Financial Summary
7. Social and Economic Summaries		
	7.1	Number of Levels of Economic Activity Controlled by Teams
	7.2	Employment Centers
	7.3	Economic Control Summary for Teams
	7.4	Social Control Summary for Teams
	7.5	Social Control Summary Totals
	7.6	Economic Graphs for Teams
	7.7	Social Graphs for Teams
8. Government Detail	8.1	Assessment Report
	8.2	Water Department Reports
	8.3	Sampling Station Report: Point Source Quality
	8.4	Sampling Station Report: Ambient Quality
	8.5	Utility Department Report
	8.6	Utility Department Finances
	8.7	Municipal Services Department Report
	8.8	Municipal Services Department Finances
	8.9	Municipal Services Department Construction Table
	8.10	Planning and Zoning Department Report
	8.11	School Department Report
	8.12	School Department Finances
	8.13	School Department Construction Table
	8.14	Highway Department Finances
	8.15	Highway Department Construction Table
	8.16	Rail Company Report
	8.17	Bus Company Report
	8.18	Chairman Department Finances
	8.19	Tax Summary
	8.20	Financial Summary
9. Summary Statistics	9.1	Demographic and Economic Statistics
10. Maps	10.1	Personal Goods Allocation Map
	10.2	Personal Services Allocation Map
	10.3	Business Commercial Allocation Map
	10.4	Municipal Service Map
	10.5	School Map
	10.6	Utility Map
	10.7	Water Usage Map
	10.8	Water Quality Map
	10.9	Municipal Treatment
	10.10	Municipal Intake and Outflow Point Map
	10.11	Surface Water Map
	10.12	Farm Runoff Map
	10.13	River Basin Flood Plain Map
	10.14	Farm Map
	10.15	Farm Assessed and Market Value Map
	10.16	Market Value Map
	10.17	Assessed Value Map
	10.18	Economic Status Map
	10.19	Highway Map
	10.20	Planning and Zoning Map
	10.21	Parkland Usage Map
	10.22	Socio-Economic Distribution Map
	10.23	Demographic Map
	10.24	Social Decision-Maker Map
	10.25	Topographical Restriction Map
	10.26	Government Status Map

Print-Out Section	Description
Personal Indexes	For each class living on each residence parcel, this shows the value of each component of the personal index based on last round's time allocation, residential crowding, MS use index, and coliform bacteria index.
Migration Detail	For each residence parcel and for each class which lived on the parcel immediately before or after the migration program ran, this shows the number of Pl's in the class now residing on the parcel and of those who moved, why they moved and where they came from and went to.
Migration Statistics	Number of in-migrants, out-migrants, internal migrants, and natural population growth by jurisdiction and class.
Migration Summary	The number of Pl's who moved between or within jurisdictions by class, by jurisdiction and by reason for moving.
2. Water System	
Water User Effluent Content	For each economic activity and municipal water system, the volume of effluent dumped into the surface water and the amount of each pollutant in the effluent after the effluent has received any treatment.
River Quality During Surface Water Process	For each of the five stages in the surface water process and for the surface water on each parcel through which a river flows, this shows the water quality rating, the volume of water, and the amount of each pollutant present.

Print-Out Section	Description
Water User Costs and Consumption	This shows for each economic activity the amount of water which it required, the amount which it obtained from its normal source and the cost which it paid to purchase water, to treat its intake water, to recycle water and to treat its effluent.
Coliform and Pollution Index Values	Map showing, for each parcel containing surface water, the coliform count and the water quality rating. The pollution indexes for such parcels and for parcels bordering parcels containing surface water are also shown.
3. Employment	
Employment Selection Information for Low-Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the route used to travel to work whether by auto or public transit.
Employment Selection Information for Middle Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the routes used to travel to work whether by auto or public transit.

Print-Out Section	Description
Employment Selection Information For High Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the routes used to travel to work whether by auto or public transit.
Part-Time Work Allocation For High Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time units spent working, and the yearly salary rate.
Part-Time Work Allocation for Middle Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time time units spent working and the yearly salary rate.
Part-Time Work Allocation for Low Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time time units spent working and the yearly salary rate.
Employment Summary	Information by class and total for the number of Pl's employed at their design level or at lower levels, the number unemployed, the total number of Pl's, the part-time units worked, and the number of jobs full time that were not filled by the local labor force.
4. Commercial Allocation	
Personal Goods Allocation Summary	Tabular output showing the identification number assigned to each PG establishment, its

Print-Out Section	Description
	location, owner, level, effective capacity, actual capacity used, price, and gross sales. For each customer it shows the store to which it is assigned, the customer location and type or class, the customer's owner, the consumption units (including those for maintenance and recreation), transportation costs (shadow costs in the case of residences) the purchase cost (total cost in the case of residences), and total cost.
Personal Services Allocation Summary	This is identical in format to the Personal Goods Allocation Summary but gives details regarding personal services.
Business Goods Allocation Summary	For businesses which require business goods, the format is the same as for personal goods. In addition, there is a section called Government Contracts which shows, for each school and MS department, how many consumption units it purchases from each business goods establishment.
Business Services Allocation Summary	This is identical in format to the Business Goods Allocation Summary but gives details regarding business services.
Terminal Allocation Summary	Tabular list of the location, business type (land use), and terminal requirements of each terminal user. Each terminal is assigned an identification number and its location, level, and usage are noted.

Print-Out Section	Description
Terminal Allocation Map	Map showing the code number of the terminal to which each terminal user in the local system is assigned.
5. Social Sector*	
Dollar Value of Time	This table shows, by team and by class, the dollar value of a time unit spent in travel.
Social Decision-Maker Output	By jurisdiction, by social decision-maker, and by class, a table in which each social characteristic is a row and each residence parcel is a column. The characteristics are descriptive and financial.
Social Boycotts	Detail on who is boycotting, what function they are boycotting, and similar details about social boycotts appear on this output.
6. Economic Sector**	
Farm Output	Tabular list, one row per farm, showing the farm code number, farm type, number of parcels comprising the farm, number of percents of parcels comprising the farm, the farm's fertilizer level, normal income, actual income, land taxes, and total net income.

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*The dollar value of time prints a table for each jurisdiction, although at this time the value is set for a team and class without regard to jurisdiction. The rest of the social detail prints in order of jurisdiction number, within that in alphabetical order, and within that in order of class (low first, high last). Output for any classes which a team does not control in a jurisdiction is not printed. Likewise, a class having no boycotts receives no boycott output.

**The economic output prints by team in alphabetical order. All of a single team's output is printed before the next team's output begins. A team for which a section of output is irrelevant does not receive that section of output. For example, a team with no residences receives no residence output. Likewise, a team which has no loans outstanding as either a debtor or a creditor does not receive a loan summary. All active teams receive financial summaries.

Print-Out Section	Description
Residence Output	Tabular list of descriptive and financial information about each residence parcel which the decision-maker controls.
Business Output	Tabular list of descriptive and financial information about each business which the decision-maker controls. All basic industries are grouped together and precede the group of personal commercial and business commercial.
Construction Industry Output	Tabular list of descriptive and financial information about each construction industry which the decision-maker controls.
Construction Industries' Contract Table	Description of all contracts made by construction industries controlled by the decision-maker.
Economic Boycott Status	Detail on all boycotts in which the decision-maker is either the party boycotting or the party being boycotted.
New Construction Table	Detail on all construction contracts in which the decision-maker is the contractee.
Land Summary	Tabular list of the location of parcels owned by a team, their assessed value, percent that is undeveloped and private, the taxes on undeveloped land, the percent publicly developed and undeveloped, the percent undevelopable because of topographical constraints, the utility capacity available and used.

Print-Out Section	Description
Loan Statement	Tabular list showing borrower, lender, interest rate, years remaining on the loan, the original principal, and the annual payment.
Financial Summary	A cash flow statement showing expenditures and income, a portfolio of conservative and speculative stocks, a balance sheet of assets and liabilities, and the amount which the decision-maker can borrow.
7. Social and Economic Summaries	
Number of Levels of Economic Activity Controlled by Teams	A table listing the number of levels of each economic activity controlled by each team.
Employment Centers	Table showing the locations, number of job openings, number of Pl's hired, and salaries offered by Federal-State Employers; table showing, for each local government employer, the location of its employment center.
Economic Control Summary*	For each non-farm economic activity, this table shows its location, type and operating level of activity, production index (0-100) or occupancy rate (0-120), net income, and rate of return.

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*This table prints for each economic team in alphabetical order.

Print-Out Section	Description
Social Control Summary*	For each class living on each parcel controlled by a single two-letter social decision-maker, this table shows the residence location, class, gross income per worker, family savings and total dissatisfaction (quality of life index).
Social Control Summary	By jurisdiction and by class, the number of P1's controlled by each social decision-maker.
Economic Control Summary	This prints two graphs for each economic decision-maker, in alphabetical order. The first is, for up to ten rounds, the average net income from the team's economic activities each round, expressed as a ratio of the first round's net income. The second is a ten-round history of the average rate-of-return of the team's economic activities, expressed as a percent.
Social Control Summary	This prints two graphs for each social decision-maker, in alphabetical order. The first is a ten-round history of the average net income earned by each class which the team has controlled. The second is a ten-round history of the average quality-of-life index of each class which the team has controlled.

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*This table prints for each social decision-maker in alphabetical order.

Print-Out Section	Description
8. Government Detail*	
Assessment Report	List of assessment ratios, special assessments and other policies set by the Assessor.
Water Department Reports	List of intake and outflow treatment plant locations, levels, types, capacities, operating costs, volume treated, income, intake and outflow point locations, prices charged to municipal water users, pollutant concentration in municipal effluent (for those districts which are sampled).
Sampling Station Report: Point Source Quality	For those economic activities whose effluent is sampled by the local government, this shows the volume of effluent and the concentration of each pollutant after any treatment.
Sampling Station Report: Ambient Quality	For any parcel on which the jurisdiction measures the quality of the surface water leaving the parcel, this output shows the concentration of each pollutant.
Utility Department Report	Tabular list of utility plants, their location, level, units installed from each plant, units served, total operating costs per unit, and income derived from charges. Also listed is the charge per utility unit to customers, undeveloped land and outstanding bonds.

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*A department's output is printed for all jurisdictions before the next department's output is printed.

Print-Out Section	Description
Utility Department Finances	Summary of all current and capital revenues, expenditures, and new balances.
Municipal Services Department Report	Tabular list of MS locations, maintenance levels, value ratios, effective capacities, loading (units of capacity used), number PL and PM's working, and the MS use indexes. Also shown are the salary levels, contracts to purchase BG and BS, the locations of undeveloped land, and outstanding bonds.
Municipal Services Department Finances	Summary of all current and capital revenues, expenditures, and new balances.
Municipal Services Department Construction Table	For each MS construction or demolition, this shows the location of the construction firm, the MS location, the status of construction, the old and new level of the MS, the contracted price, the maintenance level, and the number of PL's and PM's assigned to work at the MS.
Planning and Zoning Department Report	Total jurisdiction population, total amount of parkland, outstanding bonds, and capital revenues, expenditures, and new balance.
School Department Report	Tabular data on school unit locations, levels, maintenance levels, value ratios, students attending, teachers, student-teacher ratios, and use indexes. Also data on undeveloped land, BG and BS contracts and cost of purchases, adult education summary, and several summary school statistics.
School Department Finances	Summary of all current and capital revenues, expenditures, and new balances.

Print-Out Section	Description
School Department Construction Table	For each school construction or demolition, this shows the location of the construction firm, the school building location, the status of construction, the old and new level of the school, the contracted price, the amount of federal-state aid used, the maintenance level for the school, and the number of PM's and PH's assigned to work at the School.
Highway Department Report	A financial report showing capital and current expenditures and revenues, outstanding bonds, a summary of maintenance levels and expenditures by road type, a summary of road conditions, a terminal status report, a list of undeveloped land, and a status report on available federal-state aid.
Highway Department Construction Table	For each road or terminal construction or demolition, this shows the construction firm, the location of the road or terminal, the status, the old and new level, the contracted price, and the dollar amount of federal-state aid used.
Rail Company Report	A financial report showing capital and current revenues and expenditures, outstanding bonds, employment costs, the amount and condition of rolling stock, the fare structure, passengers and total fares by route, and the number of passengers using each segment of each route.

Print-Out Section	Description
Bus Company Report	A financial report showing capital and current revenues and expenditures, outstanding bonds, employment costs, the amount and condition of rolling stock, the fare structure, passengers and total fares by route, and the number of passengers using each segment of each route.
Chairman Department Finances	This shows the welfare payment per unemployed worker and the financial summaries for municipal services, schools, highways, planning and zoning, utilities, and the chairman's account. Also included are the Chairman's outstanding bonds.
Tax Summary	Tabular list showing by the eight types of local tax bases, the dollar amount of the tax base, the tax rate, and the revenue generated.
Financial Summary	Tabular list, for each department, of current and capital appropriations, federal-state aid, total revenue, total expenditures and final surplus or deficit.
9. Summary Statistics	
Demographic and Economic Statistics	Tabular list by jurisdiction of population and its characteristics, land usage, housing, employment, earnings, income from the national economy, outflows to the national system, and national business cycle effects.

Print-Out Section	Description
10. Maps	
Personal Goods Allocation Map	Map showing the locations and code numbers of all personal goods establishments, locations of all PG users, and the code number of the PG to which each PG user is assigned.
Personal Services Allocation Map	Map showing the locations and code numbers of all personal services establishments, locations of all PS users, and the code number of the PS to which each PS user is assigned.
Business Commercial Allocation Map	Map showing the locations and code numbers of all business goods and business services establishments, locations of all BG and BS users, and the code numbers of the BG and BS to which each BG and BS user is assigned.
Municipal Service Map	Map showing the locations of MS's and their districts, the locations of economic activities, the number of MS units drained by each economic activity and MS use indexes.
School Map	Map showing the locations of schools and their districts, school use indexes, and the number of children on each residence parcel attending public and private schools.
Utility Map	Map showing the locations of utility plants and their districts, the number of utility units installed on each parcel, and the number of utility units drained on each parcel.

Print-Out Section	Description
Water Usage Map	Map showing the locations of economic activities, the percent recycling at basic industries, and the type and level of basic industries' effluent treatment plants.
Water Quality Map	Map showing the locations of economic activities, the surface water quality on those parcels having surface water, and the pollutant which caused the water quality rating.
Municipal Treatment Plant Map	Map showing locations, types and levels of municipal intake and outflow treatment plants.
Municipal Intake and Outflow Point Map	Map showing locations of municipal intake and outflow points and the utility districts which they serve.
Surface Water Map	Map showing, for each parcel having surface water, the volume of water on the parcel, its rate of flow, and the percent of the surface area of the parcel consumed by water.
Farm Funoff Map	Map showing for each farm its type and where its runoff flows into the surface water.
River Basin Flood Plain Map	Map showing the locations of river basins, the dam priority of each river basin, and the flood susceptibility of each parcel in the river basin.
Farm Map	Map showing the location of each farm, its owner, its code number, the percent of each farm parcel which is in farm use, the type of farm, and its fertilizer level.

Print-Out Section	Description
Farm Assessed and Market Value Map	Map showing, for each farm parcel, its assessed and market value and the percent of the parcel which is in farmland.
Market Value Map	Map showing, for each privately-owned non-farm parcel, the market value of 100% of the land, the market value of the privately-owned buildings, and the total market value of the privately-owned land and buildings.
Assessed Value Map	Map showing, for each privately-owned non-farm parcel, the assessed value of the privately-owned land, the assessed value of the privately-owned buildings, and the total assessed value of the privately-owned land and buildings.
Economic Status Map	Map showing the economic sector owner of each privately-owned non-farm parcel, its zoning, the type and level of economic activity, the level of utilities installed, and, for every parcel, the percent of the parcel which is privately-owned and undeveloped.
Highway Map	Map showing the locations and types of roads and terminals and the locations, types, and levels of non-farm economic activities.
Planning and Zoning Map	Map showing the zoning classification of those parcels which are zoned, the percent of each parcel which is parkland, and the percent of each parcel which is public, institutional land.

Print-Out Section	Description
Parkland Usage Map	Map showing the percent of each parcel which is in parkland or public institutional use, the population served by the park, and the park's use index.
Socio-Economic Distribution Map	Map showing, for each residential parcel, the type and level of housing and the number of Pl's in each class living there.
Demographic Map	Map showing the population (in 100's), percent occupancy, and quality index (QI) for all residential parcels, and the value ratio (VR) for all private nonresidential developments.
Social Decision-Maker Map	Map showing, for each class living on a residential parcel, the social decision-maker which controls the class on that parcel.
Topographical Restriction Map	Map showing the percent of each parcel which is undevelopable due to topographical or other restrictions (e.g., mountains or military bases).
Government Status Map	Map showing the locations and levels of schools, municipal services, utility plants, roads, and terminals.

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